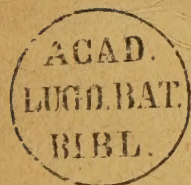


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FOSSIL FOOTPRINTS OF THE JURA-TRIAS OF NORTH AMERICA.



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11. FOSSIL FOOTPRINTS OF THE JURA-TRIAS OF NORTH AMERICA.

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(Read November 4, 1903.)

"Sans doute nous devons admirer le fait qu'une créature si insignifiante peut laisser des traces si claires, si nettes et si indélébiles, qui existent depuis des cycles de siècles innombrables, tandis que les efforts les plus grands de l'homme intellectuel lui peuvent survivre à peine et que peu de siècles anéantissent son nom, son langage et ses oeuvres pour toujours."—
(Winkler, after Deane.)

INTRODUCTION.

THE study of ichnology has practically lain dormant since the death, in 1864, of Edward Hitchcock, the founder of the science and its greatest exponent. Since that time our knowledge of early reptiles, especially the Dinosauria, has arisen and it has seemed wise to undertake anew the study of footprints in the light of modern palaeontology, with the view not only of gaining a greater insight into the nature and structure of the forms which frequented the ancient mud flats and beaches of Triassic days, but also of throwing light upon the correct interpretation of the remains of those evidently allied forms whose bones are known. Thus, on seeing the great collection in the Hitchcock ichnological cabinet of Amherst college, Professor Osborn was at once struck with the possibilities of which it gave promise and suggested to the writer the line of research of which this dissertation is the first fruit.

The writer has had full access, through the courtesy of the authorities of Amherst college and of Dr. Edward Hitchcock, Jr., in particular, to the above named collection and also to that of Mt. Holyoke college. Other lesser collections, namely, those of Rutgers college and of Lafayette college, which contain some of the type specimens, have been placed at the author's disposal, the only regret being that the magnificent gathering of footprints brought together by the late Professor Marsh of Yale university is as yet inaccessible to the student.

Free use has been made of Hitchcock's great works, the Ichnology of New England ('58) and the Supplement ('65), as well as of the numerous other papers on the subject, due notice of which appears in the proper place. The drawings, with one or two exceptions, have been made by the author directly from nature, their final preparation for publication being the result of Mrs. Lull's skillful and painstaking endeavor. Special acknowledgment is due to Dr. O. P. Hay for his valued counsel in the solution of some vexatious

problems of synonymy, but above all for his admirable Bibliography and catalogue of the fossil Vertebrata of North America (:02) which proved a great aid in the preparation of the bibliography.

The writer is also under obligations to Prof. A. Smith Woodward, of the British museum, for a superb photograph of *Chirotherium* tracks, to Prof. C. H. Hitchcock for further notes on some of his species of footprints, to Professor Emerson for notes on the geology of the Connecticut valley, and to many others who, by their suggestions, have aided the work. Finally, to my friend and teacher, Professor Osborn, my gratitude is especially due for his sympathetic advice and criticism and for the great fund of knowledge concerning these early forms, of which he was ever ready to impart.

HISTORICAL SKETCH.

An excellent résumé of the whole progress of ichnology has been given by C. Winkler in his "*Histoire de l'ichnologie*" ('86), but a sketch of the development of the science, especially in this country, may not be out of place.

Discovery.—Footprints were first discovered in 1812 or 1813 in the Bunter sandstone, at Dumfries, Scotland, but not until 1828 was the first description, that written by Duncan, given to science. The famous *Chirotherium* footprints from Hildburghausen, in Saxony, were first mentioned in 1834 in a communication by Reinhard Bernhardt to the *Neues jahrbuch für mineralogie*, and were first described by J. Kaup in the same publication in 1835.

Another very important discovery was that of the Storeton footprint quarry near Liverpool, England, first described by Cunningham, Yates, and Edgerton in the London and Edinburgh philosophical magazine, in 1838. This locality has yielded an interesting *Chirotherium* of a later stage of evolution than *C. barthi*, and in addition there are numerous tridactyl tracks of which a study is yet to be made.

Before the discovery of the Storeton remains, those of the Connecticut valley had been found, their true nature recognized, and the first notice recorded in the American journal of science and arts, in 1836. Winkler says, in speaking of the former discoveries: "By these impressions of divers feet, the existence of reptiles and of amphibians which have left their traces in the rocks, has been proved; now it is the impressions of the feet of birds which have been found in the new red sandstone of Massachusetts."

While Hitchcock was apparently the first to treat the Connecticut valley impressions from a scientific point of view, yet to Dr. Deane ('44b), of Greenfield, Massachusetts, belongs the credit of discovery, though he believed the tracks to be those of a turkey, and

did not appreciate the full significance of the remains until Hitchcock had published his views.

Collections.— Extensive collections were made, most of the specimens finding a resting place in the Hitchcock ichnological cabinet which contains most of the type specimens and representatives of almost every known species.

Later collections were formed at Mount Holyoke college and at Yale university. The latter collection, made under the direction of the late Professor Marsh, is said to rival that of Amherst college itself, though the specimens are as yet unavailable for study owing to lack of exhibition space. It is earnestly hoped that provision for the study and display of this collection will soon be made and the results given to science.

Literature.— Three monumental works on the subject of ichnology were published by President Hitchcock during his life and they form the classics of the literature of the science. The first bore the title, "An attempt to discriminate and describe the animals that made the fossil footmarks of the United States, and especially of New England," and was published in the Memoirs of the American academy of arts and sciences, 1848. The second work was the "Ichnology of New England," a large quarto, published in 1858, by the Commonwealth of Massachusetts. This was followed in 1865 by the "Supplement to the Ichnology of New England," also published by the Commonwealth. These are in addition to numerous papers published by Hitchcock in the American journal of science and arts, and elsewhere, in all some eighteen titles.

A posthumous work by Dr. James Deane entitled, "Ichnographs from the sandstone of Connecticut river," published in Boston, in 1861, is a very interesting volume consisting in the main of admirably executed drawings and photographs of the tracks. The memoir itself is incomplete and adds but little to our knowledge of the subject.

Classifications.— An historical review of the various classifications that have been proposed will be of interest in that they show the evolution of the subject from its inception down to the year 1889, when the last important paper was published. The first classification was proposed by E. Hitchcock ('37b) and it will be observed that the names were given to the tracks and not to the animals which made them. This classification was as follows: —

ICHNITES.

A. TETRAPODICHNITES.

1. *T. didactylus*.

B. SAUROIDICHNITES.

- | | |
|---|-----------------------------|
| 1. <i>S. barrattii</i> . | 3. <i>S. minitans</i> . |
| 2. <i>S. palmatus</i> (formerly <i>Ornithichnites</i>
<i>palmatus</i>). | 4. <i>S. polemarchius</i> . |
| | 5. <i>S. tenuissimus</i> . |

C. ORNITHICHNITES.

a. Pachydactyli.

- | | |
|--------------------------|--|
| 1. <i>O. giganteus</i> . | 4. <i>O. parallelus</i> (formerly <i>O. tuberosus</i> , var.
<i>dubius</i>). |
| 2. <i>O. tuberosus</i> . | |
| 3. <i>O. parvulus</i> . | 5. <i>O. divaricatus</i> . |
| | 6. <i>O. cuneatus</i> . |

b. Leptodactyli.

- | | |
|---|------------------------------|
| 1. <i>O. ingens</i> . | 6. <i>O. minimus</i> . |
| 2. <i>O. robustus</i> (<i>O. ingens minor</i>). | 7. <i>O. crassus</i> . |
| 3. <i>O. diversus</i> , var. <i>clarus</i> . | 8. <i>O. minusculus</i> . |
| “ “ “ <i>platydactylus</i> . | 9. <i>O. tetradactylus</i> . |
| 4. <i>O. deanii</i> . | 10. <i>O. gracilis</i> . |
| 5. <i>O. tenuis</i> . | |

Another classification was that published in 1844 (E. Hitchcock, '44a) embracing foreign as well as American species.

1. Tetrapodichnites; footprints of quadrupeds, containing among other forms, *Chirotherium*, *Batrachoidichnites* (*Batrachopus*) *deweyi*.

2. Dipodichnites; footprints of bipeds.

A. In America.

a. Sauroidichnites; resembling the tracks of saurians. 11 species.

b. Ornithoidichnites; resembling the tracks of birds.

1. Pachydactyli, with thick digits. 4 species.

2. Pachydactylo-pterodactyli, with thick digits having thin edges. 2 species.

3. Leptodactyli, with long and slender digits. 15 species. In all, 32 species.

B. In Europe.

1. Tridactyls in Shropshire and Cheshire.
2. Tridactyls in Saxony.

In 1845, Hitchcock ('45b) published a new series of names, those of the animals that made the tracks and not of the tracks themselves. This nomenclature was succeeded later by another, as Hitchcock considered that he had a right to change his published names at will. Following the usage of Hay in his Bibliography and catalogue of the fossil Vertebrata of North America (:02), this paper of 1845 is taken as the basis of the true nomenclature of the ichnites, all subsequent names being considered as synonyms and the old track names disregarded. The classification of 1845 is as follows:—

I. STRUTHIONOIDAE.

1. Eubrontes. 5 species. (Ornithoidichnites.)

II. PTEROPODIDAE.

2. Fulicopus. 2 species. (Ornithoidichnites.)

III. PENTEDACTYLIDAE.

3. Sauropus. 1 species. (Sauroidichnites.)

IV. TETRADACTYLIDAE.

4. Polemarchus. 1 species. (Sauroidichnites.)
5. Plectropus. 2 species. “
6. Harpedactylus. 1 species. “
7. Ancyropus. 2 species. “
8. Palamopus. 1 species. “
9. Sillimanius. 4 species. (Ornithoidichnites.)
10. Triaenopus. 2 species. (Sauroidichnites.)

V. TRIDACTYLIDAE.

11. Steropoides. 3 species. (Ornithoidichnites.)
12. Argoides. 4 species. “
13. Platypterna. 3 species. “
14. Calopus. 1 species. “
15. Typopus. 1 species. (Sauroidichnites.)
16. Batrachopus. 2 species. (Batrachoidichnites.)

The last classification proposed by Edward Hitchcock is that given in the *Ichnology*, in 1858, and this remained unchanged until 1889 when his son, Prof. C. H. Hitchcock ('89b), brought forth a new one in which dinosaurs were first recognized as the possible makers of many of the tracks. This classification was republished in Professor Emerson's *Geology of Old Hampshire county, Massachusetts* ('98, p. 400-403) and owing to error was the same as that of 1889 though it was supposed to have been revised. In a letter to the present author, dated April 3d, 1903, Professor Hitchcock submits the intended revision of 1898 in which four genera with fifteen species are removed from the Dinosauria and are placed once more with the leptodactylous birds which would seem to be rather a retrogressive step in spite of the fact that the word "birds" is preceded by an interrogation point. C. H. Hitchcock ('89b) would call dinosaurs only such as show front feet, heels, or tails. Moreover, he considers birds long legged and dinosaurs short of limb, although short as well as long limbed birds exist, while dinosaurs as a rule were rather long legged and certainly the great majority of cursorial forms among them were capable of long strides when well under way.

E. Hitchcock's classification of 1858 divided the forms into the following groups:—

Group I.—MARSUPIALOID ANIMALS.

Anomoepus, etc., 3 genera.

Group II.—PACHYDACTYLOUS OR THICK TOED BIRDS.

Brontozoum, Grallator, etc., 3 genera.

Group III.—LEPTODACTYLOUS OR NARROW TOED BIRDS.

1. Tridactylous,—Argozoum, etc. 2. Tetradaactylous,—Ornithopus, etc., 4 genera.

Group IV.—ORNITHOID LIZARDS OR BATRACHIANS.

Gigantitherium, Plesiornis, etc., 7 genera.

Group V.—LIZARDS.

Plectropterna, etc., 11 genera.

Group VI.—BATRACHIANS.

Otozoum, etc., 10 genera.

Group VII.—CHELONIANS.

Chelonoides, etc., 5 genera.

Group VIII.—FISHES.

Ptilichnus, 1 genus.

In all, forty-four genera and ninety-three species. In Charles Hitchcock's classification, while the dinosaurian group was recognized, yet the carnivorous dinosaurs which may be correlated with the *Anchisauridae*, or primitive carnivorous dinosaurs, were still retained under the head of pachydactylous birds, an extremely conservative view; while only such as exhibited either manus or tail were referred to the reptilian group.

The classification proposed in the present memoir, which will be given later, refers by far the greater number of the species to the dinosaurs, though to what order some of the obscure tracks belong is by no means certain; in fact it may never be fully known. Certain of the truly quadrupedal forms may, with fair assurance, be referred to the Proterosauria of Seeley¹ from their very dinosauroid pes, while others, so far as any evidence which the tracks offer is concerned, might as readily be referred to almost any of the reptilian orders. The presence of Stegocephalian Amphibia or Batrachia cannot be definitely proven as yet.

GENERAL DISCUSSION.

Introduction.—In the red and gray sandstones and shales of the Connecticut valley, and in certain parts of New Jersey and elsewhere, have been found numerous indications of the ancient beings which peopled those localities in bygone ages. These indications take the form of impressions of some part of the body of these early forms, either of dermal appendages such as scutes and callosities, or of dragging portions of the body, such as the traces made by the tail; but by far the most numerous of all are the prints of the feet which render to the student a fairly complete knowledge of the size, proportions, and habits of their maker and, coupled with the knowledge gained through other sources, give us a considerable insight into the morphology of the feet and the affinities of the forms themselves.

That both vertebrate and invertebrate creatures were here represented is certain; but, with the exception of the class Reptilia among the former, which group contains by far the greater number of the tracks, it is rather difficult to assign the forms to their proper classes.

It was formerly supposed that certain parallel traces were made by the fins of fishes whose remains are found somewhat abundantly in certain localities. This interpretation has since been doubted and the traces relegated to the group of doubtful genera. Amphibians may have been present, but there are no tracks which can with absolute certainty be referred to them and the same may be said of the birds though the present

¹ "A very primitive group related to the Rhynchocephalia from which the dinosaurs may have arisen." (Osborn.)

author has sought earnestly for avian indications. The class Mammalia seems also to be unrepresented.

Among the reptile tracks the majority seem to be dinosaurian in origin and are referable to both the Theropoda, or carnivorous dinosaurs, and the Orthopoda, or herbivorous forms; the great Sauropoda, herbivorous quadrupedal forms of the Jurassic, either not having appeared or having been so truly aquatic and of such vast bulk that they could not wander over the shallow water flats and beaches where the tracks were formed. Certain quadrupedal tracks show strong Theropod affinities and were doubtless formed either by primitive dinosaurs or by the Diaptosaurian progenitors of that group which survived side by side with the more specialized forms. Again, certain of the footmarks show lizard-like characters, though no lizards are known from so remote a time; others are Chelonoid while yet others seem to be related to, or at least to resemble, early crocodiles.

Many of the tracks are beautifully preserved, showing even the most delicate tegumentary impressions and it is upon these that the author has spent the larger part of his time in the endeavor to learn the structure of the foot. Other of the remains are in some instances extremely obscure and give little or no insight into their maker's form, but in the revision of the fauna it became necessary to treat them as fully as conditions would permit, but with very unsatisfactory results.

Geological age and conditions.—The geological age of the beds in which the ichnites are found is generally conceded to be upper Triassic, equivalent to the Keuper and Rhaetic of Europe, a correlation which is based upon the remains of fossil plants and of fishes which they contain. From the evidence of the footprints themselves it is apparent that the dinosaurs had already reached a high degree of adaptive radiation and specialization, which would argue against the reference of the formations to any earlier period.

The remains are found in at least two of the ten Triassic areas as enumerated by Dana ('95, p. 741) and of these the classic locality is the valley of the Connecticut river in a belt ranging from the village of Northfield, Massachusetts, to New Haven bay, a distance of one hundred and ten miles, and with a width of about twenty miles.

The New Jersey localities are in the Palisade belt which extends from the Hudson river, through New Jersey, Maryland, and Pennsylvania, to Virginia.

The Connecticut valley belt is clearly of estuarine formation with the tidal ebb and flow of water. It was also subject, locally at least, to conditions of flood which brought down coarser débris from the surrounding country, as the sudden change in the character of certain strata from shale to coarse sandstone gives evidence. An instance of this occurs in the Otozoum beds of South Hadley, Massachusetts, where the layers upon which the animals walked were so soft and fine in texture as to be incapable of preservation

while the overlying hard sandstone several inches in thickness preserves upon its under surface the footprints in high relief. This is paralleled in the *Chirotherium* localities in Hessburg, Saxony, and at Storeton quarry, in England.

Most of the footprint localities were well out in the ancient bay and were evidently tidal flats which were daily left bare by the ebbing waters as the occasional record of a shower of rain associated with the footprints gives evidence. The presence, at times, of ripple marks and other littoral features lends weight to the tidal theory.

Three factors aided in the preservation of these remarkable remains. First, the fierce heat of a tropical sun, for the plant fossils are sufficient evidence of such climatic conditions. Emerson ('98, p. 379) says that all of the famous localities were out in the ancient bay in sandstones that rest directly on the back of the broad trap sheets and not very high above them and that the heat which emanated from the not yet cooled lava together with the iron which was liberated by its decomposition constitute two very efficient agents, the second and the third, for the preservation of the impressions.

Skeletal remains.—With the exception of fishes, the actual vertebrate fossils are extremely rare, but few localities having yielded them. Such as have been found are the remains of dinosaurs and they seem to indicate that the great majority of the carcasses which found their way into the water were swept out to sea by the tide and irrevocably lost, or that the conditions were not right for their preservation. The rarity of the remains would argue in favor of terrestrial as opposed to either wholly or partially aquatic habits on the part of these forms.

Dinosaurian characters in the tracks.—The assumption that the majority of the vertebrate tracks are those of dinosaurs seems readily proven though the proof of the non-existence of birds is rather more difficult than the elimination of other vertebrates. The foot characters wherein the birds and the dinosaurs agree are: first, the digitigrade, functionally tridactyl pes, though in both groups the foot is generally structurally tetradactyl. The phalangeal formula, 1st digit, 2; 2d digit, 3; 3d digit, 4; 4th digit, 5, is identical in each group and the order of reduction of the digits is the same, namely: first, V, the outer digit, then I, the inner digit or hallux, and never first, I, as in mammals. Another common character is the length of limb as compared with the length of the foot, a long legged form being indicated by a long stride and narrow trackway. Finally, the bipedal walk as opposed to the sprawling quadrupedal gait of the majority of modern reptiles is an annectant character.

The features which separate the tracks under consideration from those of birds are several, though all do not occur in each instance. They are: first, the presence of a tail trace which is unquestionably reptilian. This may be a continuous serpentine impression or a series of short straight ones as though the appendage were raised at each step,

or it may be a continuous, straight line impressing during the whole of the animal's walk or just before sitting on its heels as in the case of *Anomoepus intermedius*. The occasional impression of a manus is another distinguishing character and the presence of irregular dermal scutes or tubercles upon the skin, though rarely leaving a record, is certainly not avian.

Relation of pads to interphalangeal joints.—The generalized arrangement of the pads, which, with the exception of the distal articulation, are mesarthral, that is, they lie opposite the phalanges as in the human hand and not arthral with the pads opposite the joints, as in all lizards and the majority of carinate birds, characterizes the earlier dinosaurs. That this interpretation of the morphology of the foot is correct seems true for several reasons. The foot bones of *Anchisaurus colurus*, which is clearly to be correlated with the track, *Anchisauripus dananus*, will only lie in the impression in one way and that brings the pads mesarthral in position. Hatteria seems to have mesarthral pads, certainly they are not arthral and Hatteria's foot must approximate that of the dinosaurs more than any known form. Finally in certain of the Limicolae, namely *Phalaropus hyperboreus*¹ in which the foot retains its cursorial character without having become specialized for perching, the pads are arranged as in dinosaurs. The rhea has another form of specialization, for here the pads become confluent and hence fewer than the overlying bones, giving no clue to the phalangeal formula, especially on digit IV. It seems probable that among the later Iguanodont dinosaurs there was a coalescence of pads correlated with increase in weight as in the rhinoceros. The tracks of Iguanodon itself, which are known, conform with this belief.

Hitchcock's view that the distal pad of each digit covers both the penultimate and the proximal end of the ungual phalanges is undoubtedly correct. When viewed from the

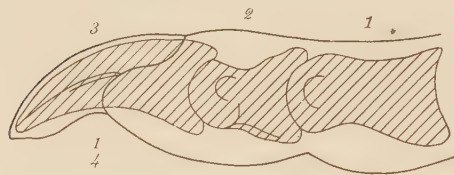


Fig. 1. Digit II of Dimodosaurus viewed in profile with the outline restored to show the relation of the claw and pads to the phalanges. From a cast in the collection of the American museum of natural history. $\times \frac{1}{4}$.

side the ungual phalanx shows a groove running from the point backward midway between the upper and lower borders until it reaches a point about half the length of the bone in a walking digit and farther backward in a grasping one. Another sinuous depression which takes a forward and downward course across the bone defines the hinder limit of the claw sheath, while into the grooves first mentioned, fit ridges on the inner surface of the claw and serve to hold it firmly in place. The fleshy part of the digit extending somewhat beyond the root of the claw thus covers a greater or less portion of the phalanx itself as well as that just within (fig. 1). In cases where

¹ Coues, Key to North American birds, 1884, fig. 53 bis.

the claw is absent the ungal as well as the penultimate phalanx must lie entirely within the distal pad as in digit I of *Chirotherium barthi* (pl. 72, fig. A).

Prehensile and locomotor terminal claws.—In the less specialized dinosaurs, even among the carnivorous forms, the anterior ungals of the pes do not seem to have borne *prehensile* claws, though such were undoubtedly borne on those of the manus and in all probability upon the hallux as well, as long as the latter remained functional. The increase in curvature of the pedal ungals and the consequent development of the claws seem to be correlated with the reduction of the manus as a prehensile organ, apparently reaching its highest expression in *Allosaurus* and the later *Megalosauria*. In *Dimodonsaurus*, a Triassic *Megalosaurian* dinosaur, the ungal phalanges are less curved than in *Allosaurus* and the facets indicate that while in the latter the ungal could be flexed through an angle of fully 90°, in the former the possible movement was very slight, as in the later *Orthopoda*.

Digital reduction in relation to the tracks.—Several stages in the digital reduction in the pes may be observed among dinosaurs, an understanding of which will aid in the interpretation of the tracks.

First, the *Anchisaurus* (a carnivorous Triassic dinosaur) stage. Here the hallux is complete, insistent, that is, only the tip of the claw touches the ground, rotated backward and probably highly efficient as a grasping claw. Digit V is represented by the proximal half of the metatarsal, and the proximal end of metatarsal II is narrow on its anterior face. This stage is represented by the track genus *Anchisauripus*.

Second, the *Compsognathus* (a carnivorous form from the Jurassic of Bavaria) stage. The hallux is complete, slender, insistent, and half rotated, functional though possibly not to so high a degree as in the preceding stage. Digit V is represented by the proximal end of the metatarsal only, and the anterior face of the upper end of metatarsal II is still narrow. This stage is represented among the footprints by *Anomoepus*, the manus and pes of which are quite like those of *Hypsilophodon*, though in *Anomoepus* the pes is much more elongate and slender.

The third stage of digital reduction is that of *Allosaurus* (a carnivorous Jurassic form) wherein the first metatarsal is not completely ossified in the shaft indicating a partial loss of function on the part of the hallux. This digit is incumbent, that is, its whole length rests on the ground, and it is little more than half rotated. Digit V seems to be obsolete and the proximal anterior face of metatarsal II is the widest. This stage is represented by *Gigandipus* among the tracks.

Fourth, the *Dryosaurus* (an herbivorous Jurassic dinosaur) stage in which the hallux is represented by the proximal half of the metatarsal only, the claw being absent. Digit V is also absent. The ichnite *Eubrontes* may belong to this stage, for the foot seems to be structurally tridactyl, the imprint of the hallux never having been observed.

The fifth stage is that of *Ornithomimus*, a Cretaceous carnivorous dinosaur, in which both lateral digits are obsolete, and with the loss of metatarsal I, metatarsal IV becomes the widest at the proximal end. *Ornithomimus* seems to be an aberrant form and strongly suggests the footprint genus *Grallator*. Most Cretaceous dinosaurs have reached this stage of absolute structural tridactylism.

Digit V is thus the first to suffer reduction being functional in no known dinosaur. Digit I follows, but more slowly, especially in the carnivorous Theropoda where its use as a prehensile claw caused it to be retained longer than in the herbivorous Orthopoda. An interesting compensation is also shown between the widening of the proximal end of metatarsal II as metatarsal V is reduced and in the same manner the widening of metatarsal IV follows the loss of that of the hallux, thus maintaining the width of the ankle joint. *Otozoum* represents a pro-*Anchisaurus* stage in its plantigrade foot and well developed, non-rotated hallux. It is more generalized than the foot of any known dinosaur.

Evidences as to gait, speed, and habits.— (a) *Non-saltatorial*. The gait of the various creatures which left their impressions on the sandstone is in most instances a true walk or run, generally bipedal, sometimes quadrupedal, and but rarely does one find evidence of a sprawling crawl, such as most modern reptiles exhibit. There is no evidence whatever among the footprints of a leaping dinosaur, that is, one in which both feet leave the ground at the same moment. *Fulicopus lyellianus*, in a fine specimen, no. $\frac{1}{7}$, of the Hitchcock ichnological museum, at Amherst (E. Hitchcock, '65, pl. 19), seems to have tried to stop so suddenly as to slide for a considerable distance before overcoming its momentum and this is the nearest approach to evidence in favor of a saltatorial form.

The Anomoepodoid forms, which include *Fulicopus* with their elongated metatarsi, have a limb whose structure approaches a saltatorial type as much as that of any other dinosaur, with the possible exception of *Hallopus* a lower Jurassic form, (Marsh, '96, p. 153), and the evidence leads one to doubt whether any dinosaurs were truly leaping in gait. Hitchcock ('58, p. 57) in speaking of *Fulicopus lyellianus* (*Anomoepus major*) says: "On one specimen in the cabinet we find the impression [of the ischial callosity, *vide infra*] repeated at the distance of ten inches, as if the animal moved by leaps." This serial repetition of the impression may have been made by the animal resting at each step while feeding as the footprints give no evidence of jumping nor is it likely that an animal would take successive leaps of ten inches when its normal stride was two and a half feet!

(b) *Semiaquatic habits*. The existence of semiaquatic forms seems to be proven by the presence of a web to the foot in several instances, the most notable being *Otozoum moodii* in which the membrane, if such it were, extended for some distance beyond the

tips of the digits, curiously paralleling *Chirotherium barthi* of Saxony (pl. 72, figs. B, G). The fact that both tracks are found in such soft shale that the impression can rarely be preserved lends color to the belief that they were at least semiaquatic in their habits. Another explanation of the web is suggested, namely to give the creature additional support in soft mud which would have its analogy in the snowshoe.

(c) *Bipedalism*. Evidence of bipedalism among dinosaurs is shown in many instances. In *Anchisauripus* the track during swift movement is tridactyl, the hallux impressing only when the creature was stopping or when the mud was especially soft. The tail in this genus never impresses but was evidently used as a counterpoise, or balancing organ.

Anomoepus, though tridactyl and truly bipedal in gait, nevertheless occasionally rested the hands upon the ground and might also drag the tail and impress the hallux for a short distance before stopping.

Otozoum was a huge, bipedal form, plantigrade and tetradactyl in gait, rarely resting the hands and sometimes dragging the tail as did *Anomoepus*.

Batrachopus was quadrupedal with a tetradactyl, very dinosauroid pes, and a much smaller, functionally tetradactyl manus. The very long, stilted limbs in this genus suggest the Dinosauria as well.

Finally in *Chirotherium* one finds a truly quadrupedal form, pentadactyl in both the manus and pes though often the former impresses so lightly as to make a tetradactyl track, as the greater part of the creature's weight was borne on the larger hind feet. This illustrates the statement of Osborn (:00, p. 796) in which he says that "tridactylism is correlated with rapid bipedal progression, the inner and outer digits suffering reduction." Among modern forms, *Chlamydosaurus*, an Australian lizard (Kent, '97) gives us the best illustration of Osborn's law, though many other lizards, when frightened, run on the hind limbs with the tail held as a counterpoise.

(d) *Possible avian footprints*. The difficulty of distinguishing a track thus formed from that of a bird led Baur ('87, p. 102) to suppose that Hitchcock was correct in believing that many of the sandstone tracks were made by true birds. It seems to the writer that, with the possible exception of some of the leptodactylous or caved-in tracks whose affinities are very obscure, one can by a method of elimination narrow the possible avian tracks down to the genus *Grallator*. In this group the relative length of foot to limb seems to be about that of the bustards, but the foot pads are much more specialized in the bird, those of the outer digit having coalesced to form one as in the struthious birds. Otherwise the foot of *Grallator* and that of *Otis* are very similar, even to the loss of the hallux. The fact that *Grallator* is cursorial rather than arboreal does not lessen the possibility of its being a bird, for the use to which the ostrich puts its wings while running

suggests the probability of the evolution of wings, in some forms at least, first as an aid to more rapid running, then to support the creature during long soaring leaps, and finally for true flight. It seems necessary to leave the question in this way until further evidence as to the true nature of *Grallator* is found.

Footprints and taxonomy.—It becomes at once clear to the student of ichnology that while the various footprint species may represent definite stages in the evolution of the foot, the number of definable genera and species must actually be far less than that of the animals which made them. Marsh ('93) shows an appreciation of this when he says, in speaking of the genera *Anchisaurus* and *Ammosaurus*: "So far as at present known the footprints of the two reptiles would be very similar differing mainly in size." (Compare figs. 4, 7.)

(a) *Variations in the impressions left by the same animal.* There are, doubtless, many instances of individual variation among dinosaurs of the same species other than those of age and sex, and in the tracks, additional causes of variation come in, such as the posture or gait of the animal or the character of the surface over which it walked. The first of these factors has a notable illustration in the slab no. $\frac{1}{1}$, of the Hitchcock museum. On this specimen are impressed among others, two tracks, the one called by Hitchcock the type of *Anomoepus major*, the other that of *Fulicopus lyellianus*, which though referred to different genera, are in all probability the impressions of the same individual! In each case the size, form, and proportions are the same even to peculiar markings, due to injury or some unusual cause, upon the sole of the foot. The difference is mainly in the hinder part of the track due to the fact that in one case the animal was seated upon its heels, raising the posterior part of the foot a little off the ground, while in the other the entire weight of the creature resting on the foot broadened it out especially beneath the metatarsals and brought another pad into the impression (figs. 26, 27).

(b) *Influence of the composition and condition of the ground.* The texture of the ground upon which the animal trod, the fineness or coarseness of the sediment and the degree of dryness are important factors. This is beautifully illustrated by the type specimen of *Anomoepus curvatus*, no. $\frac{52}{10}$ of the Hitchcock museum, of which a photograph may be seen in Hitchcock ('65, pl. 15, fig. 2). The slab contains five tracks of one animal walking down the beach toward the water, two of the tracks being above the high water mark of the previous tide and three below. That portion of the shore above the mark was drier and the tracks while well formed do not show the pad outlines and other markings as well as do the third and fourth where the surface was smoother and more moist. Finally the fifth track is much deeper and owing to an uneven surface the hinder part of the foot did not impress, altering the entire aspect of the footprint.

The so called "leptodactylous" tracks of Hitchcock were, as a rule, made in such soft mud that the subsequent caving of the sides of the impression has rendered almost unrecognizable certain well known species and as a consequence has given rise to new ones which have added to the difficulty of unraveling the synonymy. Doubtless there were creatures which frequented these soft mud flats whose remains are not found elsewhere, but it is well nigh impossible to fix their true characters. Both "pachydactylous" and "leptodactylous" tracks sometimes occur upon the same slab which may be accounted for by the supposition that time sufficient for the mud to dry out elapsed between the passage of the two animals. The presence of puddles or tide pools would account for a variable degree of dampness within a comparatively small area.

The general rarity of the narrow toed tracks and their abundance in one locality, as at Weathersfield, Connecticut, where the rock is a very fine red shale and must have been exceedingly plastic when the prints were formed, makes it extremely hazardous to erect many genera and species upon such remains.

(c) *Variations of age improbable.* It has been argued that one ought to find the tracks of young among the number and that possibly some of the so called species represent the youthful individuals of forms the adults of which made larger impressions. While this may in certain instances be true, it seems hardly probable for several reasons, among which may be mentioned the comparative constancy of size among the many individuals referable to a single group and the rarity of gradational specimens.

In some cases the adult condition of the individual is indicated by the fact that the claw impression is offset some little distance beyond the distal pad, the significance of which can be appreciated by the study of the foot of the cassowary, for example, in which, in the young, the claw and flesh impressions are united, whereas in the adult they are widely separated due to the growth of the claw. It has been suggested that the growth of dinosaurs was like that of trees, continuous throughout life until the senile condition was reached. This is true only of aquatic, poikilothermous forms in which, as some one has said, the energy which, in the bird or land mammal, is used in overcoming gravity and in the production of heat, can be turned into the growth force. The dinosaurs which frequented these shores were either land forms or, in a few cases, as that of *Otozoum*, possibly semiaquatic and it is further possible that they were warm blooded. Thus it appears highly probable that they were of limited growth.

The Sauropoda which probably had this tree-like growth are entirely absent from the footprint fauna. Hitchcock ('58, p. 41) thinks it hardly probable that "very young animals would often frequent such thoroughfares as the localities of footmarks seem to have been . . . where so many animals resorted, and where in the dearth of food that must sometimes have existed, the young ones must often have been devoured."

It is possible that the tidal flats were seasonally resorted to as breeding places and that the young were brought forth in remote spots where their footprints would not be preserved, possibly some dry, sandy place at a distance from the water. As a reason for the selection of such rookeries Hitchcock ('58, p. 19) suggests "that the eruption of the trap produced an island ridge in the waters, and the heat of the cooling rock made it a favorite resort for animals, and rapidly dried and therefore preserved their tracks in such perfection."

TAXONOMIC CHARACTERS.

The following are the characters which are used in the distinction of genera and species in ichnology.

1. Whether bipedal or quadrupedal in gait. Here one finds a gradational series, for the creatures may be absolutely bipedal, never resting the manus upon the ground, or they may be bipedal in gait and rest upon all fours. They may be quadrupedal but with the bulk of the weight borne upon the hind limbs; or they may be truly quadrupedal with a more equable division of the weight over both manus and pes.

2. The presence or absence and the character of a caudal trace. While the absence of this impression is constant in certain genera, as *Anchisauripus* and *Grallator*, its presence is a variable character and does not always appear on every specimen. In *Selenichnus* and one or two other genera it seems always to be present, but it will readily be seen that it depends largely upon the animal's gait, as in running the tail was well raised.

3. The relative size and contrasted characters of the manus and pes are very important points in the correlation of the footprint classification with that of the animals as known from other sources. Fore and hind feet are generally clearly recognizable as such, yet Hitchcock ('58, p. 102) in the genus *Plesiornis* seems to have taken the accompanying tracks of a somewhat smaller bipedal animal for those of the fore feet of a quadrupedal form. The pes seems to be generally in a more advanced stage of evolution than the manus and in the dinosaurs to be larger and much more ornithoid.

4. The distinction of the right and left foot. Where the phalangeal formula is betrayed by the pads, the number of phalanges is always as in birds, one greater than the number of the digit, thus: $\frac{I}{2}, \frac{II}{3}, \frac{III}{4}, \frac{IV}{5}$. In four toed forms where there is one backwardly pointing toe it is invariably the hallux and hence on the inside of the foot (fig. 7). In the five toed *Chirotherium* on the contrary the backwardly curved toe, or *pouce* of the French, represents the fifth digit and is upon the outside of the foot (pl. 72, figs. B, D). In the tridactyl or tetradactyl dinosaur tracks the claws of digits II and IV point away

from the axis of the foot while the claw of digit III is invariably bent inward toward the middle of the trackway. These criteria refer to isolated tracks; where there are two or more footprints in a row there is generally no difficulty in distinguishing the right from the left foot.

5. The number of digits is a valuable character for use in systematic work, though frequently the entire number does not impress, or the mark of the hallux is such as to be easily overlooked. The handprints of *Anomoepus* or of *Chirotherium* are very likely to be defective because each animal pressed so lightly with the manus.

6. The length of the toes, both actual and relative, the amount of protrusion or exsertion of the middle toe beyond the lateral ones and the distance between the tips of the latter are valuable criteria.

7. The angle of divarication of the toes is a somewhat variable character, that between the lateral ones (digits II and IV) being the most constant. This is measured by drawing lines through the axes of the digits and reading the angles of intersection with a protractor. As these points of intersection rarely coincide, the angle between the lateral toes is generally greater than the sum of the individual angles. It has been quite difficult to make the descriptions given in the present work agree absolutely with those of Hitchcock in this regard even where the same specimens have been measured.

8. The character of the claws, or their absence, is a criterion of great importance. In the dinosaurs the feeding habits have been deduced from the claw structure and hence the separation of the genera into their proper orders is largely based thereon. Thus it is impossible to imagine *Anomoepus*, with the small rounded claws on manus and pes, as having carnivorous habits, while the pointed claws and powerful hallux of *Anchisauripus* would place it among the Theropoda even if we did not associate the genus with the carnivorous *Anchisaurus*. In some cases it is quite difficult to judge, especially of the claws of the anterior digits of the pes, which, as mentioned above, only become curved trenchant weapons in proportion as those of the manus are reduced or lose their efficiency as prehensile organs. One should remember that among herbivorous ungulate mammals the *Ancylopoda*,¹ and *Agriochoerus*² are bluntly clawed forms, while *Mesonyx*, a creodont, was hoofed.

9. The presence and character of the metatarsal or "heel" impression found in the *Anomoepodidae* is a very distinctive character and the relative lengths of heel and foot give about the only definable specific distinction between *Anomoepus scambus* and *A. intermedius*.

10. Varying degrees of plantigrady and digitigrady may be noted and may thus be

¹ Beddard, Cambridge natural history, 1902, vol. 10, p. 211.

² Wortman, Bull. Amer. mus. nat. hist., 1895, vol. 7, p. 145.

defined. Plantigrade is that foot posture in which the whole sole and heel are applied to the ground in normal progression as in *Otozoum*. The term calcigrade is used by Hitchcock to define a track in which the heel impression is deeper than the anterior part of the foot. The present author would confine its use to a posture as of the sitting *Anomoepus* which in its progression is digitigrade (see figs. 19 and 20): In a digitigrade foot only the digits and the distal ends of the metatarsals are applied to the ground as in *Gigandipus*. *Anchisauripus* has the posterior part of the foot skeleton raised so high as almost to warrant the application of the term semidigitigrade being applied to it. Such a foot posture may lead to a complication of the pads seemingly without reference to the overlying bones.

Summary of taxonomic characters.—(a) *Ordinal*. Whether habitually bipedal, occasionally quadrupedal, or habitually quadrupedal. Character of claws, especially of manus. General form of manus and pes.

(b) *Generic*. Relative length of foot to limb. Width of trackway. Presence or absence of caudal trace. Relative size and contrasted characters of manus and pes. Number of digits of manus and pes. Position of hallux. Presence and character of metatarsal or heel impression. Varying degrees of plantigrady or digitigrady. Complexity of pads.

(c) *Specific*. Length of digits, actual and relative. Size of animal. Angle of divarication of digits. Peculiarities of form.

CLASSIFICATION.

The classification of the forms which made the footprints is a matter of extreme difficulty as the true nature of many of the footprint genera cannot be ascertained in the present state of our knowledge. The best that can be done in the matter is to place the more obvious forms in what seems to be their proper relationship, reserving, for the present, an expression of opinion upon the remainder of the genera. Amphibia must have inhabited the Triassic estuaries but with the possible exception of *Shepardia*, their tracks cannot be identified as of such, all of the better known forms evidently belonging to the Reptilia.

A scheme of classification based upon that proposed by Osborn (:03a) may be given as follows:—

Class REPTILIA.

Subclass DIAPSIDA Osborn.

Superorder **Diaptosauria** Osborn.Order ? *PROTEROSAURIA* Seeley.

Batrachopus Hitchcock.

deweyanus Hitchcock.*dispar* Lull.*gracilis* Hitchcock.

Batrachopus Hitchcock.

gracilior Hitchcock.*bellus* Hitchcock.

Cheirotheroides Hitchcock.

pilulatus Hitchcock.Superorder **Dinosauria** Owen.Order *THEROPODA* Marsh. (Carnivorous dinosaurs.)

Anchisauripus Lull.

dananus Hitchcock.*hitchcocki* Lull.*tuberosus* Hitchcock.*exsertus* Hitchcock.*minusculus* Hitchcock.*parallelus* Hitchcock.*tuberatus* Hitchcock.

Gigandipus Hitchcock.

caudatus Hitchcock.

Hyphepus Hitchcock.

fieldi Hitchcock.

Grallator Hitchcock.

cursorius Hitchcock.*tenuis* Hitchcock.*cuneatus* Hitchcock.*formosus* Hitchcock.*gracilis* Hitchcock.

Stenonyx Lull.

lateralis Hitchcock.

Selenichnus Hitchcock.

falcatus Hitchcock.*brevisculus* Hitchcock.Order *ORTHOPODA* Cope. (Herbivorous dinosaurs.)

Anomoepus Hitchcock.

scambus Hitchcock.*intermedius* Hitchcock.*curvatus* Hitchcock.*crassus* C. H. Hitchcock.*minimus* Hitchcock.*gracillimus* Hitchcock.

Anomoepus Hitchcock.

cuneatus C. H. Hitchcock.*isodactylus* C. H. Hitchcock.

Fulicopus Hitchcock.

lyellianus Hitchcock.

Apatichnus Hitchcock.

circumagens Hitchcock.

Apatichnus Hitchcock.	Eubrontes Hitchcock.
<i>minus</i> Hitchcock.	<i>divaricatus</i> Hitchcock.
Corvipes Hitchcock.	<i>platypus</i> Lull.
<i>lacertoides</i> Hitchcock.	Otozoum Hitchcock.
Eubrontes Hitchcock.	<i>moodii</i> Hitchcock.
<i>giganteus</i> Hitchcock.	? <i>parvum</i> C. H. Hitchcock.
<i>approximatus</i> C. H. Hitchcock.	

Order *INCERTAE SEDIS*.

a. Forms habitually bipedal.

Argoides Hitchcock.	Plesiornis Hitchcock.
<i>isodactyletus</i> Hitchcock.	<i>pilulatus</i> Hitchcock.
<i>macrodactylotus</i> Hitchcock.	? <i>mirabilis</i> Hitchcock.
<i>redfieldianus</i> Hitchcock.	? <i>giganteus</i> C. H. Hitchcock.
<i>robustus</i> Hitchcock.	Polemarchus Hitchcock.
Platypterna Hitchcock.	<i>gigas</i> Hitchcock.
<i>deaniana</i> Hitchcock.	Sillimanius Hitchcock.
<i>concamerata</i> Hitchcock.	<i>tetradactylus</i> Hitchcock.
<i>digitigrada</i> Hitchcock.	<i>gracilior</i> Hitchcock.
<i>tenuis</i> Hitchcock.	Steropoides Hitchcock.
<i>delicatula</i> Hitchcock.	<i>elegans</i> Hitchcock.
<i>recta</i> Hitchcock.	<i>ingens</i> Hitchcock.
Tarsoplectrus Lull.	<i>infelix</i> Hay.
<i>angusta</i> Hitchcock.	<i>loripes</i> Hitchcock.
<i>elegans</i> C. H. Hitchcock.	<i>uncus</i> Hitchcock.
	Lagunculapes Hitchcock.
	<i>latus</i> Hitchcock.

b. Forms occasionally quadrupedal.

Xiphopeza Hitchcock.	Tarsodactylus Hitchcock.
<i>triplex</i> Hitchcock.	<i>caudatus</i> Hitchcock.
	<i>expansus</i> C. H. Hitchcock.

Subclass SYNAPSIDA Osborn.

Order *TESTUDINATA*.

(The reference of the following to this order is somewhat doubtful.)

Chelonoides Hitchcock.	Helcura Hitchcock.
<i>incedens</i> Hitchcock.	<i>anguinea</i> Hitchcock.
Amblypus Hitchcock.	<i>littoralis</i> Hitchcock.
<i>dextratus</i> Hitchcock.	<i>surgens</i> Hitchcock.
	Ancyropus Hitchcock.
	<i>heteroclitus</i> Hitchcock.

INCERTAE SEDIS.

a. Forms habitually quadrupedal.

Eupalamopus Hay.	Antipus Hitchcock.
<i>dananus</i> Hitchcock.	<i>flexiloquus</i> Hitchcock.
Palamopus Hitchcock.	<i>bifidus</i> Hitchcock.
<i>anomalis</i> Hitchcock.	Isocampe Hitchcock.
<i>divaricans</i> Hitchcock.	<i>strata</i> Hitchcock.
<i>rogersianus</i> Hitchcock.	Shepardia Hitchcock.
Exocampe Hitchcock.	<i>palmipes</i> Hitchcock.
<i>arcta</i> Hitchcock.	Comptichnus Hitchcock.
<i>minima</i> Hitchcock.	<i>obesus</i> Hitchcock.
Orthodactylus Hitchcock.	Arachnichnus Hitchcock.
<i>floriferus</i> Hitchcock.	<i>dehiscens</i> Hitchcock.
<i>introvergens</i> Hitchcock.	Triaenopus Hitchcock.
<i>linearis</i> Hitchcock.	<i>baileyanus</i> Hitchcock.
Sustenodactylus Lull.	Cunichnoides Hitchcock.
<i>curvatus</i> Hitchcock	<i>marsupialoides</i> Hitchcock.

SYSTEMATIC DESCRIPTIONS.

Class REPTILIA.

Subclass DIAPSIDA Osborn.¹Superorder Diaptosauria Osborn.¹Order? *PROTEROSAURIA* Seeley.

*Ordinal characters.*² Quadrupedal in gait; manus generally much smaller than the pes and five fingered though all may not always impress. Pes with four digits, generally dinosauroid in form, though plantigrade. Limbs generally long.

These forms seem to represent survivors of the ancient stem from which the dinosaurs arose; they may, however, represent primitive quadrupedal dinosaurs which had not yet acquired the erect gait.

Family **BATRACHOPODIDAE**.

Family characters. The same as those given for the order. Digits of the pes with acuminate claws.

Genus **Batrachopus** E. Hitchcock. (Frog foot.)

Batrachopus E. Hitchcock, '45b, p. 25.

Anisopus E. Hitchcock, '48, p. 226.

Anisichnus C. H. Hitchcock, '71, p. xxi, (to replace *Anisopus* preoccupied).

Generic characters. Manus probably with five, always with four broad clawless digits, generally directed forward.

Pes four toed; the hallux non-rotated; all of the digits bearing slender acuminate claws; that of the fourth toe may be absent in the impression, possibly also in the foot; third toe the longest. Manus and pes tracks close together and nearly in a right line. Ratio of track to step, one to seven nearly.

This genus was included by Hitchcock under the Loricoid marsupialoids from its supposed likeness to an armored marsupial. Type species, *B. deweyanus*, E. Hitchcock.

¹ Osborn, : 03a.

² The characters here given are based entirely upon the tracks; for further definition of the orders, etc., the student is directed to Zittel's Palaeontologie.

Batrachopus deweyanus E. Hitchcock.

Batrachopus deweyanus E. Hitchcock, '45b, p. 25.

Anisopus deweyanus E. Hitchcock, '48, p. 226; '58, p. 60, pl. 9, fig. 3; pl. 41, fig. 2; pl. 43, fig. 1-2; pl. 53, fig. 8; pl. 58, fig. 11.

Specific characters. Pes: divarication of digits I and II, 12° ; of II and III, 23° ; of III and IV, 6° ; of I and IV, 40° . Length of digit I, .025 m.; of II, .038 m.; of III, .043 m.; of IV, .038 m.; of the foot, .043 m. Distance between the tips of the lateral toes, .028 m.

Manus: divarication of digits I and II, 53° ; of II and III, 13° ; of III and IV, 18° ; of IV and V, 24° ; of I and V, 107° . Length of digit I, .008 m.; of II, .020 m.; of III, .025 m.; of IV, .025 m.; of V, .015 m. Distance between lateral tips, .019 m. Length of step, .100 to .113 m. Width of trackway, .050 to .075 m.

This is a somewhat variable species, but in at least one specimen, no. $\frac{21}{1}$, of the Hitchcock cabinet, the variation is so great that it has been deemed wise to erect a new species for its reception.

Type specimens: nos. $\frac{26}{5}$ and $\frac{26}{6}$, of the Hitchcock cabinet on hard gray shale. Type locality not recorded, but the species is reported from Middletown, Connecticut.

Batrachopus dispar sp. nov.

Specific characters. Pes: divarication of digits I and II, 18° ; of II and III, 20° ; of III and IV, 22° ; of I and IV, 60° . Length of digit I, from the middle point of the heel, .046 m.; of II, .067 m.; of III, .072 m.; of IV, .062 m. Distance between lateral tips, .053 m. Length of foot, .073 m. The digits all bear slender claws except the fourth which is clawless. The toes are broad and the heel is of considerable width as the bulk of the weight was borne upon it. Length of step, .230 m.

Manus: but four digits impressing. Divarication of digits I and II, 26° ; of II and III, 68° ; of III and IV, 20° ; of I and IV, 122° . Length of foot, .030 m. Distance between tips of the lateral toes, .028 m. The manus of this form is about equal in size to that of *B. deweyanus*, while the pes is twice as large. The name *dispar* is given on account of the great disparity in size of the fore and hind feet (fig. 2).

The type is no. $\frac{21}{1}$, of the Hitchcock cabinet, on red shale from the Lily pond at Turner's Falls, Massachusetts.



Fig. 2. *Batrachopus dispar* Lull. Impressions of the left manus and pes. $\times \frac{1}{2}$. Drawn from the type specimen, no. $\frac{21}{1}$, in the Hitchcock cabinet.

Batrachopus gracilis (E. Hitchcock).

Anisopus gracilis E. Hitchcock, '48, p. 228, pl. 16, fig. 3-4; '58, p. 61, pl. 9, fig. 4; pl. 35, fig. 5; pl. 36, fig. 1-5; pl. 58, fig. 9.

Anisichnus gracilis C. H. Hitchcock, '89b, p. 119.



Specific characters. Pes: divarication of digits I and II, 23° ; of II and III, 20° ; of III and IV, 30° ; of I and IV, 73° . Length of digit I, .011 m.; of II, .021 m.; of III, .023 m.; of IV, .031 m. Length of foot, .036 m. Distance between lateral tips, .028 m. All of the digits are clawed. The variation of the figured specimen, no. $\frac{5.5}{107}$, from Hitchcock's described type is mainly in the divarication, never a constant factor.

Manus: divarication of digits I and II, 23° ; of II and III, 25° ; of III and IV, 44° ; of IV and V, 62° . Length of digit II, .012 m.; of III, .013 m.; of IV, .011 m.; of V, .004 m. The pollex rarely impresses and often the fifth digit is obscure giving practically a functionally tridactyl track. There seems to be a wide range of variation in divarication in the manus as well. Length of step, .209 m. Manus placed just in advance of the pes.

This form is smaller than either of the preceding species (fig. 3).

The type specimen is no. $\frac{42}{3}$, of the Hitchcock cabinet, on a slab of dark shale whose locality is unrecorded. The species is reported from Massachusetts, Connecticut, New Jersey, and Pennsylvania.



Fig. 3. *Batrachopus gracilis* E. Hitchcock. Successive tracks of right and left manus and pes, showing the relative length of step to foot impression. $\times \frac{1}{2}$. From the type specimen, no. $\frac{42}{3}$, of the Hitchcock cabinet.

Batrachopus gracilior (E. Hitchcock).

Anisopus gracilior E. Hitchcock, '63a, p. 54; '65, p. 6, pl. 1, fig. 3.

Anisichnus gracilior C. H. Hitchcock, '89b, p. 119.

Specific characters. Pes: divarication of digits I and II, 14° ; of II and III, 11° ; of III and IV, 15.5° . Length of digit I, to center of heel, .009 m.; of II, .0125 m.; of III, .014 m.; of IV, .015 m. Length of foot, .015 m. Distance between lateral tips, .012 m.

Manus: divarication of digits I and II, 35° ; of II and III, 37° ; of III and IV, 11° ; of IV and V, 77° . Length of digit I, from center of the rear of the track, .005 m.; of II, .008 m.; of III, .008 m.; of IV, .007 m.; of V, .005 m. Length of foot, .008 m. Length of step, .046 m. Width of trackway, .05 m. Ratio of foot to stride, as one to three.

This form is distinguished from *B. gracilis* by its smaller size and much shorter limbs and wider body, in fact it seems somewhat doubtful whether the species should properly be referred to this genus; it surely is not a typical *Batrachopus*.

Type specimen, no. $\frac{46}{3}$, of the Hitchcock cabinet, on reddish shale; locality unrecorded.

Batrachopus bellus (E. Hitchcock).

Apatichnus bellus E. Hitchcock, '58, p. 101, pl. 17, fig. 6; pl. 35, fig. 8; pl. 45, fig. 6.

Specific characters. Pes: divarication of digits II and III, 30°; of III and IV, 30°. Length of digit I, .005 m.; of II, .010 to .018 m.; of III, .020 to .025 m.; of IV, .015 to .020 m. Length of foot, .026 m.

Manus: divarication of outer toes, 40°. Length of foot, .013 m. Length of step, .100 to .170 m. Width of trackway, .063 m. Ratio of foot to step, about one to six on the average.

This form is long of limb and strictly quadrupedal in gait though the light impression of the manus is not always discernible. The latter character removes it from *Apatichnus* and both characters would tend to ally it with *Batrachopus*. In size it lies between *B. gracilis* and *B. gracilior* but the length of limb would place it nearer the former.

The type is no. $\frac{26}{21}$, of the Hitchcock cabinet, on red shale, from Turner's Falls, Massachusetts.

Genus ***Cheirotheroides*** E. Hitchcock. (Chirotherium-like.)

Cheirotheroides E. Hitchcock, '58, p. 130, pl. 23, fig. 4; pl. 36, fig. 6; pl. 54, fig. 3.

Generic characters. Quadrupedal in gait; feet unequal in size, pes functionally tetradactyl, manus pentadactyl. The three inner digits of the pes generally terminate in pellets, the fourth digit does not. The presence of a fifth digit to the pes is apparently indicated in some specimens, but rarely impresses itself. The limbs are rather short, the ratio of foot to step being as three to four, though the length of step varies.

Cheirotheroides pilulatus E. Hitchcock.

Cheirotheroides pilulatus E. Hitchcock, '58, p. 130, pl. 23, fig. 4; pl. 36, fig. 6; pl. 54, fig. 3.

Specific characters. Pes: divarication of digits I and II, 10°; of II and III, 15°; of III and IV, 15°. Length of digit I, .010 m.; of II, .014 m.; of III, .018 m.; of IV, .018 m. Length of foot, .225 m. Distance between lateral tips, .014 m.

Manus: divarication of digits I and II, 57°; of II and III, 60°; of III and IV, 28°; of IV and V, 20°. Length of digit I, .004 m.; of II, .008 m.; of III, .009 m.; of IV, .006 m.; of V, .004 m. Length of step, .320 m. Width of trackway, .570 m.

This species resembles *Batrachopus gracilior* most closely, especially in the short limbs and broad body, but differs therefrom in the pellet-like character of the claws. It may be that the last character is of specific value only and that the two forms mentioned should be brought together under one genus. The present species is extremely rare and is in need of further study before its true character can be learned. It seems best to place it under the Proterosauria because of its pentadactyl manus which Gadow claims is never found among the Amphibia. However, it seems quite far removed from the typical *Batrachopus*.

Type specimen, no. $\frac{34}{44}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts. This is specimen no. $\frac{34}{31}$ of the Ichnology.

Superorder **Dinosauria** Owen.

*Ordinal characters.*¹ Bipedal in gait. Pes ornithoid, structurally tri- or tetradactyl, though generally functionally tridactyl. Manus never impressing (Megalosauria), or occasionally resting upon the ground (Orthopoda), but never used for locomotion. Manus pentadactyl. Caudal trace sometimes present.

Order *THEROPODA* Marsh.

Strictly bipedal, digitigrade forms, with a tetradactyl mesaxonic foot, functional, subfunctional, or vestigial hallux. Claws acuminate but not strongly recurved in Triassic forms. Limbs moderately long and trackway narrow. Occasional tail trace.

Family **ANCHISAURIPODIDAE**.

Footprints of dinosaurs of the family Anchisauridae.

Family characters. Bipedal, tetradactylous; hallux, when impressing, rotated to rear, insistent. Well marked phalangeal pads; anterior claws acuminate, but not strongly raptorial. No manus nor caudal impressions. But one genus: *Anchisauripus*.

Genus **Anchisauripus** gen. nov. (Foot of *Anchisaurus*.)

Eubrontes E. Hitchcock, '45b, p. 23 (in part).

Brontozoum E. Hitchcock, '47, p. 50 (in part).

¹ Definition applying to Connecticut valley dinosaurs.

Generic characters. Bipedal, tetradactylous; hallux rotated to the rear so as to lie in line with the claw of the second digit, insistent, that is, inserted high on the leg so that only the tip of the claw impresses and that only when the weight is borne on the hinder part of the foot. The hallux evidently bore a well developed, subfunctional, grasping claw. Foot of moderate size with well marked phalangeal pads. Limbs of medium length. Manus and tail never impressing.

This genus is clearly correlated with the *Anchisaurus* and *Ammosaurus* of Marsh and is here separated from Hitchcock's genus *Eubrontes* (*Brontozoum*) the latter being retained for the larger herbivorous forms which were grouped with the carnivorous species.

The type species is *Anchisauripus dananus* (*Brontozoum sillimanium*, in part, of the Ichnology) the track of *Anchisaurus colurus* Marsh.

***Anchisauripus dananus* (E. Hitchcock).**

Eubrontes dananus E. Hitchcock, '45b, p. 23 (in part).

Brontozoum sillimanium E. Hitchcock, '47, p. 49; '58, p. 68, pl. 12, fig. 3; pl. 33, fig. 4-5; pl. 43, fig. 6, (in part).

Specific characters. Divarication of digits I and II, 139° ; of II and III, 11° ; of III and IV, 18° . Length of digit I, .050 m.; of II, .077 m.; of III, .115 m.; of IV, .088 m. Length of foot, not including the hallux, .153 m.; with the hallux, .187 m. Distance between lateral tips, .067 m. Length of step, from .300 to .560 m. Width of trackway, .115 m.

The type specimen is no. $\frac{9}{14}$, of the Hitchcock cabinet; reddish flagging stone from Middletown, Connecticut. Figured in F. A. Lucas, :01, figure 7.

This is undoubtedly the track of *Anchisaurus colurus* Marsh ('96, p. 148, pl. 2, fig. 1-3; pl. 3, fig. 1-2) from the exact way in which the bones fit the track (fig. 4).

This is an extremely common and variable species, the variations consisting in size, complexity of heel pads, breadth and divarication of toes, and the shape of the claws. E. Hitchcock ('58, p. 69) in speaking of this form says: "I have found it difficult to define the limits of this species and I apprehend that as now given it embraces at least two species. But I have failed to seize upon any distinctive characters between them." It seems to

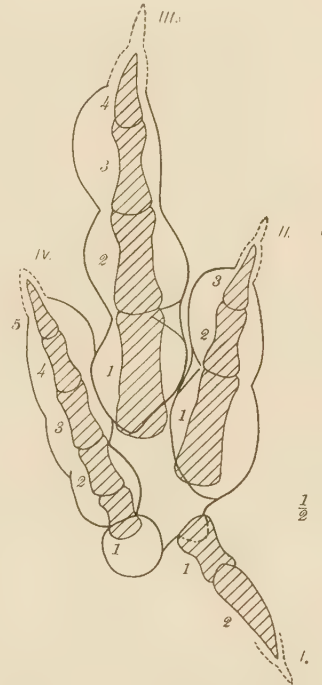


Fig. 4. *Anchisauripus dananus* E. Hitchcock. Impress of the left pes. $\times \frac{1}{2}$. From the type, no. $\frac{9}{14}$, of the Hitchcock cabinet. The skeleton is based upon that of *Anchisaurus colurus* Marsh.

the present author that a division can be made upon the ground of size, though whether this would agree with what Hitchcock had in mind one cannot say. There are, however, certain specimens whose size agrees with what one would expect the pes of *Anchisaurus* (*Megadactylus*) *polyzelus* E. Hitchcock, Jr., to be, judging from the relative sizes of the known part of the skeleton and that of *A. colurus*, and it is proposed to place these specimens under a new species bearing the name of *Anchisauripus hitchcocki* in honor of the great ichnologist.

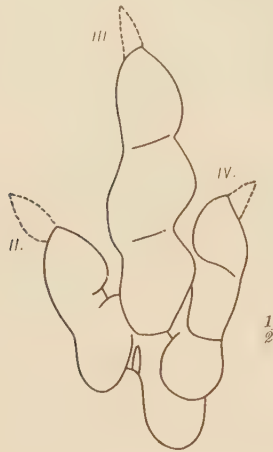


Fig. 5. *Anchisauripus hitchcocki* Lull. Impression of the right pes. $\times \frac{1}{2}$. From the type specimen, no. $\frac{56}{1}$, of the Hitchcock cabinet.

lateral tips, .067 m. (see fig. 5).

The type specimen is an individual track, no. $\frac{56}{1}$, of the Hitchcock cabinet, associated with *A. minusculus* and is figured by E. Hitchcock ('65, pl. 16, fig. 1). On shale, from the Lily pond, at Turner's Falls, Massachusetts.

This species is correlated with *Anchisaurus* (*Megadactylus*) *polyzelus* E. Hitchcock, Jr., the first dinosaur found in the valley, the type of which is preserved in the Hitchcock ichnological cabinet at Amherst.

***Anchisauripus tuberosus* (E. Hitchcock).**

Eubrontes tuberosus E. Hitchcock, '45b, p. 23.

Brontozoum loxonyx E. Hitchcock, '48, p. 172, pl. 2, fig. 1-2.

Brontozoum validum E. Hitchcock, '58, p. 67, pl. 12, fig. 2; pl. 38-51; pl. 57, fig. 3.

Specific characters. Divarication of digits I and II, ? 135° ; of II and III, 14° ; of III and IV, 13° . Length of digit I, about ? .055 m.; of II, .086 m.; of III, .128 m.; of IV,

***Anchisauripus hitchcocki* sp. nov.**

Synonymy as in *A. dananus*.

Specific characters. Divarication of digits I and II, 138° ; of II and III, 19° ; of III and IV, 14° ; of II and IV, 33° . Length of digit II, .060 m.; of III, .088 m.; of IV, .075 m.; of the foot, exclusive of hallux, .119 m.; including the hallux, .140 m. Distance between

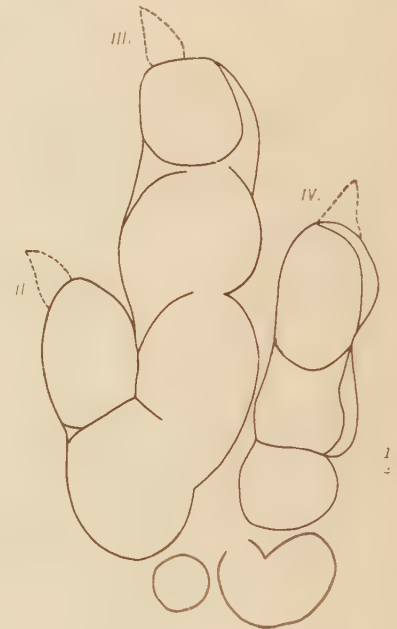


Fig. 6. *Anchisauripus tuberosus* E. Hitchcock. Track of the right pes. $\times \frac{1}{2}$. From the type, no. $\frac{34}{1}$, of the Hitchcock cabinet. The hallux impression is restored from another specimen.

.120 m. Length of foot exclusive of hallux, .168 m.; with the hallux, ? .195 m. Length of step, .440 m. Other specimens than the type show measurements somewhat in excess of those given above.

This is a very numerous and variable type, in size between *Anchisauripus dananus* and *A. exsertus*, with no marked peculiarities other than size to distinguish it from either. The type specimen, no. $\frac{31}{73}$, of the Hitchcock cabinet, a superb track, has unfortunately been trimmed in such a way as to destroy the impression of the first claw, but the basal pad of the hallux is clearly impressed. It is figured in the Ichnology on plate 57, figure 3. Specimen no. $\frac{16}{1}$, while somewhat larger, gives all of the characters, including the hallux.

Type, no. $\frac{31}{73}$, of the Hitchcock cabinet, on red shale from Turner's Falls, Massachusetts (fig. 6).

***Anchisauripus exsertus* (E. Hitchcock).**

Brontozoum exsertum E. Hitchcock, '58, p. 67, pl. 12, fig. 1; pl. 40, fig. 3.

Specific characters. Based on no. $\frac{54}{1}$. Divarication of digits I and II, 75° ; of II and III, 20° ; of III and IV, 20° . Length of digit I, .075 m.; of II, .117 m.; of III, .161 m.; of IV, .153 m. Length of foot, exclusive of hallux, .226 m.; including the hallux, .265 m. Length of step in no. $\frac{16}{6}$ (a somewhat larger specimen), .922 m.

The real distinction between this species and *A. tuberosus* seems to be one of size only, for the character which gives the name "*exsertus*," that of the unusual projection of the middle toe beyond the lateral ones, is not always manifest. This species is correlated with *Ammosaurus major* Marsh ('96, p. 147, pl. 3, fig. 3-6).

Type specimen, no. $\frac{16}{6}$, of the Hitchcock cabinet, on gray micaceous sandstone from Smith's Ferry, Massachusetts (fig. 7, of no. $\frac{54}{1}$).

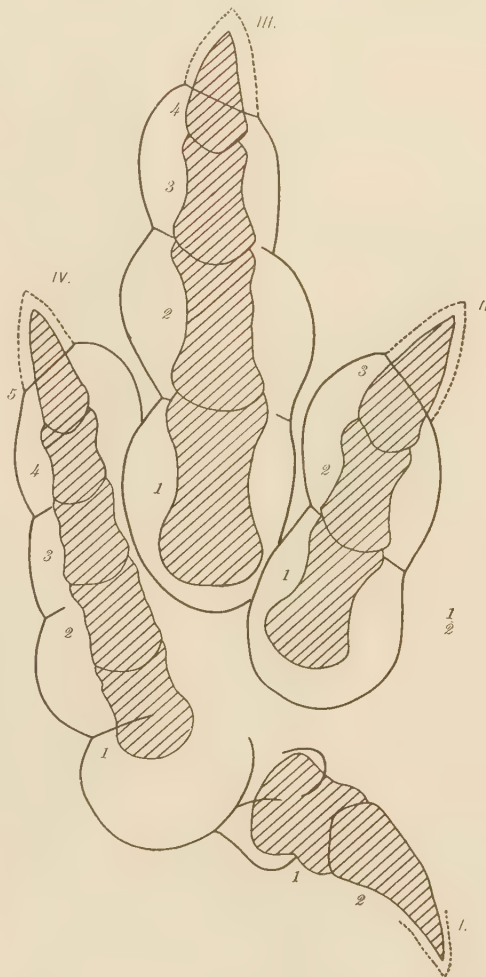


Fig. 7. *Anchisauripus exsertus* E. Hitchcock. Imprint of the left pes. $\times \frac{1}{2}$. From no. $\frac{54}{1}$, of the Hitchcock cabinet. The bone restoration is after that by Marsh of *Ammosaurus major* Marsh.

Anchisauripus minusculus
(E. Hitchcock).

Brontozoum minusculum E. Hitchcock, '58, p. 65, pl. 11, fig. 1; pl. 40, fig. 2; pl. 41, fig. 1; pl. 42, fig. 3; pl. 57, fig. 2.

Specific characters. Divarication of digits I and II, 140° ; of II and III, 24° ; of III and IV, 24.5° . Length of digit I, .100 m.; of II, .158 m.; of III, .192 m.; of IV, .223 m. Length of foot, exclusive of the hallux, .307 m.; including the hallux, .374 m. Length of step, 1.000 m.

This magnificent form is the largest of the genus and indicates an animal about twice the size of *Anchisaurus colurus*, which would give it a length of about fourteen feet.

The type specimen, the one here figured (fig. 8), is no. $\frac{16}{1}$, from the Hitchcock cabinet, on fine red shale from the Lily pond at Turner's Falls, Massachusetts.

Anchisauripus parallelus
(E. Hitchcock).

Grallator parallelus E. Hitchcock, '65, p. 7, pl. 5, fig. 1.

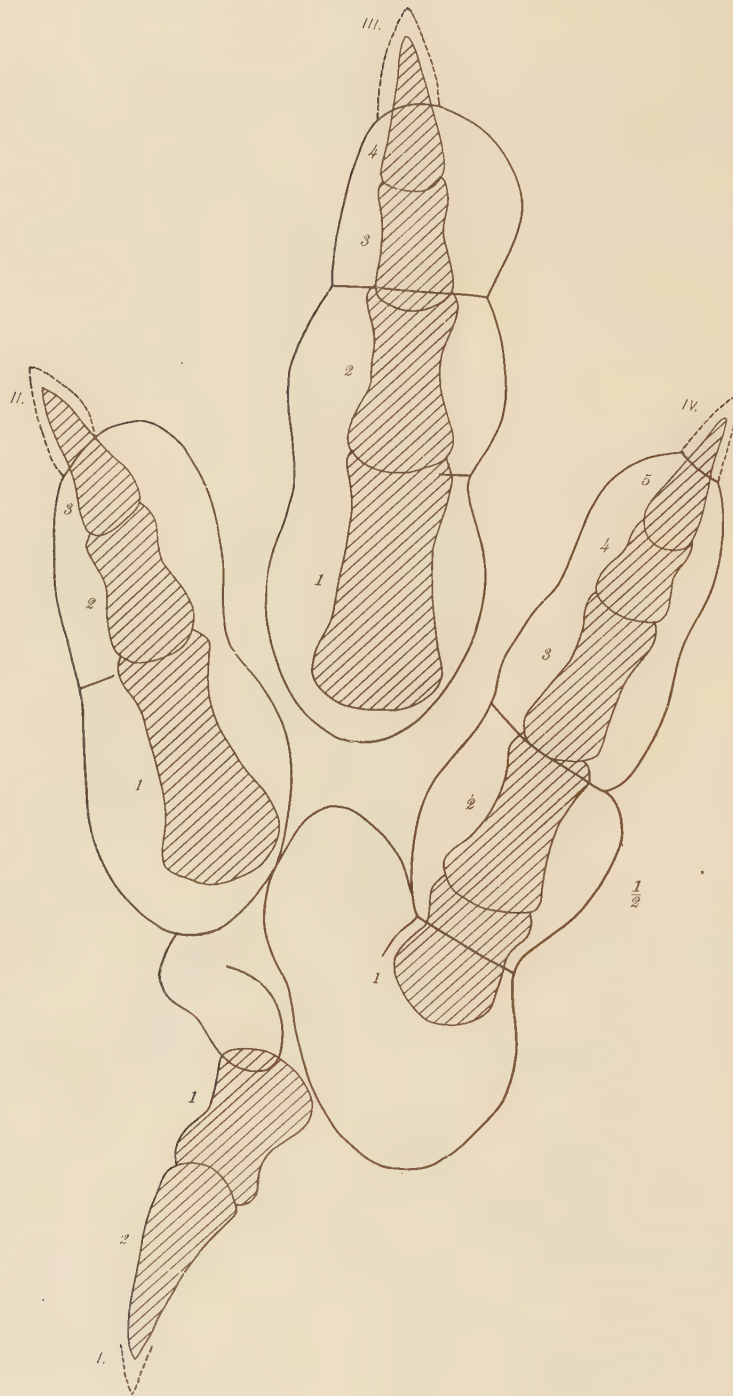


Fig. 8. *Anchisauripus minusculus* (E. Hitchcock). Track of the right pes with a restoration of the bones of the foot. $\times \frac{1}{2}$. Drawn from the type, no. $\frac{16}{1}$, in the Hitchcock cabinet.

Specific characters. Divarication of digits I and II, 141° ; of II and III, 12° ; of III and IV, 6.5° . Length of digit I, .067 m.; of II, .079 m.; of III, .120 m.; of IV, exclusive of "heel" pad, .090 m. Length of foot exclusive of the hallux, .165 m.; including the hallux, .210 m. Length of step, .260 m.

This form is evidently not a *Grallator* from the shortness of step and the wide trackway. The presence of the hallux removes it from *Grallator* and associates it with *Anchisauripus*, though the presence of the three heel pads separates it from *A. dananus*, its nearest ally in point of size. It is also peculiar in the slight divarication of the toes, hence the specific name (fig. 9).

Type, no. $\frac{54}{8}$, of the Hitchcock cabinet, on red sandstone from Gill, Massachusetts; also reported from New Jersey.

***Anchisauripus tuberatus* (E. Hitchcock).**

Brontozoum tuberatum E. Hitchcock, '58, p. 66, pl. 11, fig. 2; pl. 52, fig. 7.

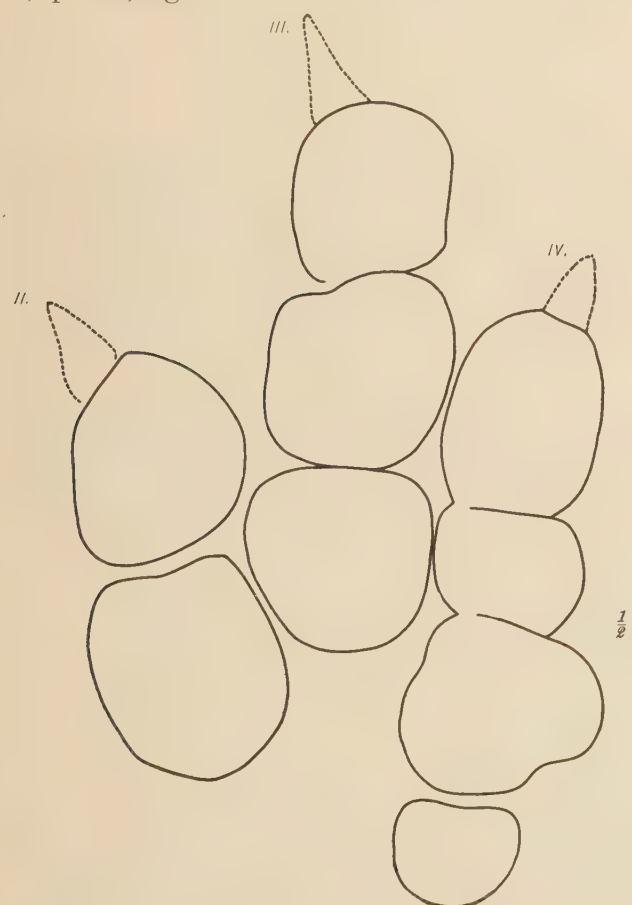


Fig. 10. *Anchisauripus tuberatus* (E. Hitchcock). Impress of the right pes. $\times \frac{1}{2}$. From the type, no. $\frac{27}{17}$, in the Hitchcock cabinet.

Specific characters.

Divarication of digits I and II, not known; of II and III, 17° ; of III and IV, 8° . Length of digit II, .140 m.; of III, .172 m.; of IV, .107 m.

Length of the foot, exclusive of hallux, .249 m. Distance between lateral tips, .152 m.

This species resembles *A. exsertus* in size, being but little larger, but the two forms are readily distinguished by the broad tuberous phalanges of the one in question. In general character, the

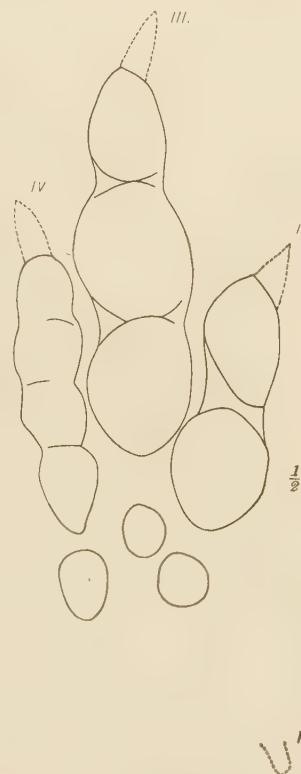


Fig. 9. *Anchisauripus parallelus* (E. Hitchcock). Impress of the left pes. $\times \frac{1}{2}$. From the type, no. $\frac{54}{8}$, of the Hitchcock cabinet.

foot is annectant between *Anchisauripus* and *Eubrontes*, the acuminate claws and small size alone among the known characters affiliating it with the former. Unfortunately, the type specimen, no. $\frac{27}{17}$, has been so trimmed as to destroy the hallux impression if it were present so that the presence or absence of this characteristic mark cannot be ascertained (fig. 10).

The type, no. $\frac{27}{17}$, of the Hitchcock cabinet, is on red shale from Turner's Falls, Massachusetts.

Family **GIGANDIPODIDAE**.

Family characters. Large bipedal forms. Tetradactyl, hallux half rotated, incumbent. Foot flatly digitigrade. Claws acuminate. No manus impression. Caudal trace sinuous and continuous. Genera: *Gigandipus*, possibly also *Hyphepus*.

Genus **Gigandipus** E. Hitchcock. (Giant foot.)

Gigandipus E. Hitchcock, '55, p. 417 (no description).

Gigandipus E. Hitchcock, '56, p. 97.

Gigantitherium E. Hitchcock, '58, p. 93.

Generic characters. Bipedal, tetradactyl, hallux incumbent, that is, inserted low on the leg so that its whole length is on the ground; rotated at right angles to the second toe. Hallux but feebly developed. Foot with distal ends of metatarsals upon the ground in contrast to *Anchisauripus* in which the foot rests upon the toes only. Claws acuminate; that of digit II especially strongly developed. Tracks nearly in a right line. Caudal trace sinuous and continuous.

The foot of this form agrees very closely in structure with that of *Allosaurus* (Osborn, '00, p. 785, fig. 4) and it was from the limb of that genus (American museum of natural history, fossil reptile collection, no. 290) that the studies for the bone restoration of *Gigandipus* were made.

Gigandipus caudatus E. Hitchcock.

Gigandipus caudatus E. Hitchcock, '55, p. 417 (no description).

Gigandipus caudatus E. Hitchcock, '56, p. 97, text figs.

Gigantitherium caudatum E. Hitchcock, '58, p. 93, pl. 16, fig. 1-2; pl. 44, fig. 4.

Specific characters. Divarication of digits I and II, 98° ; of II and III, 22° ; of III and IV, 30° . Length of digit I, .080 m.; of digit II, to metatarsal pad, .215 m.; including the pad, .280 m.; of III, to metatarsal pad, .275 m.; of IV, to the pad, .290 m.;

including the metatarsal pad, .343 m. Length of foot, .445 m. Distance between the tips of the lateral toes, .285 m. Length of step, 1.020 m. Width of trackway, .305 m.

Although this is one of the largest of the Connecticut valley tracks, that of *Allosaurus* would far exceed it in size for the estimated length of the footprint of the latter would be at least .720 m., as against .445 m. for the *Gigandipus*.

Type specimens, nos. $\frac{9}{9}$ and $\frac{9}{10}$, of the Hitchcock cabinet, on reddish shale from the Lily pond, Turner's Falls, Massachusetts (fig. 11).

The second species of *Gigandipus*, the *G. minor* of Hitchcock, has been removed to *Apatichnus* for which it seems to possess greater affinities.

Genus **Hyphepus** E. Hitchcock. (Web foot.)

Hyphepus E. Hitchcock, '58, pp. 97, 189.

Generic characters. Bipedal, tetradactylous track. Hallux incumbent, curving sharply backward. There seems to be a web between the anterior toes and they are apparently clawless, except the third. No phalangeal pads are visible on any of the specimens. Caudal trace present, generally passing through the footprints.

This form occurs at the same horizon with *Gigandipus*, which it resembles except for its smaller size, the presence of the web and the apparently clawless condition of the lateral digits. It is placed provisionally near *Gigandipus* though the relationship may not be a very close one.

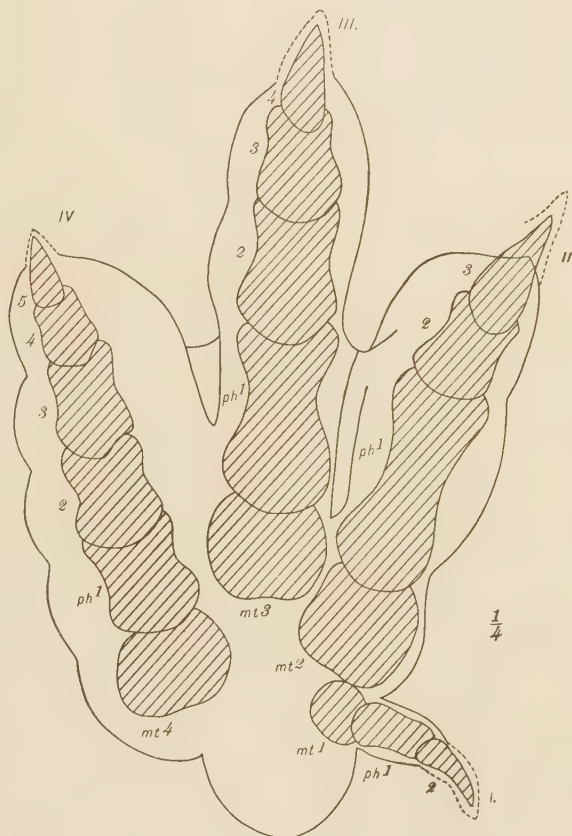


Fig. 11. *Gigandipus caudatus* E. Hitchcock. Imprint of left pes. $\times \frac{1}{4}$. From the type specimen, no. $\frac{9}{10}$, in the Hitchcock cabinet. The bone restoration is based upon the foot of *Allosaurus*, slightly modified from the mounted specimen, no. 290, of the fossil reptile collection of the American museum of natural history.

Hyphepus fieldi E. Hitchcock.

Hyphepus fieldi E. Hitchcock, '58, pp. 97, 189, pl. 17, fig. 2; pl. 35, fig. 11; pl. 41, fig. 2; pl. 42, fig. 2.

Specific characters. Divarication of digits I and II, 118° ; of II and III, 23° ; of III and IV, 28° ; of II and IV, 50° . Length of digit I, .026 m.; of II, .077 m.; of III, .078 m.; of IV, .083 m. Length of foot, .128 m. Distance between lateral tips, .071 m. Length of step, .153 m. Width of trackway, .135 m.

Type, no. $\frac{1}{3}$, of the Hitchcock cabinet on micaceous shale from Turner's Falls, Massachusetts.

Family GRALLATORIDAE.

Family characters. Small bipedal forms; footprint tridactyl, limbs very long; no manus nor caudal impression. Genus: Grallator; possibly also Stenonyx.

Genus **Grallator** E. Hitchcock. (One who goes on stilts.)

Grallator E. Hitchcock, '58, p. 72.

Generic characters. Bipedal, tridactyl tracks; tail trace absent (an apparent exception to this in a specimen referred to *Grallator gracilis*); long limbs and small compact feet. Claws acuminate, moderately developed.

This genus is distinguished from *Anchisauripus*, which it most closely resembles, by the length of limb, smallness of track and the absence of a hallux. It suggests in proportions the Cretaceous genus, *Ornithomimus*, and is about the only group of pachydactylous tracks which could possibly be referred to birds, some species suggesting the bustards though in the latter group the pads on digit IV are specialized by coalescence and all seem to be arthral as opposed to the mesarthral pads of *Grallator*. The association of the long limbed *Grallator* with the amphibious *Otozoum* suggests possible wading habits on the part of the former.

Type species, *Grallator cursorius* E. Hitchcock.

Grallator cursorius E. Hitchcock.

Grallator cursorius E. Hitchcock, '58, p. 72, pl. 13, fig. 3; pl. 58, fig. 4.

Specific characters. Divarication of digits II and III, 14° ; of III and IV, 12° ; of II and IV, 26° . Length of digit II, .035

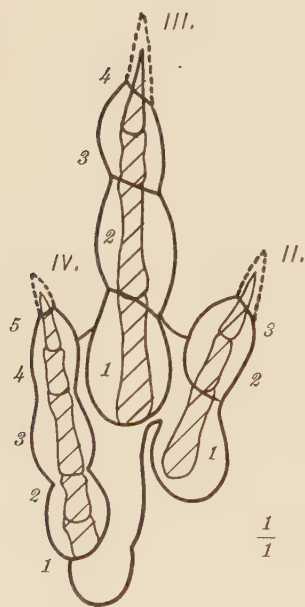


Fig. 12. *Grallator cursorius* E. Hitchcock. Impression of the left pes. $\times \frac{1}{2}$. With a restoration of the skeleton. Drawn from no. 1 of the Hitchcock cabinet.

m.; of III, .055 m.; of IV, .045 m. Length of foot, .079 m. Distance between lateral tips, .031 m. Projection of the middle toe beyond the others, .033 m. Length of step, .610 m., giving a ratio of foot to step of about one to eight. Width of trackway, .050 m.

The figured specimen, no. $\frac{4}{1}$, of the Hitchcock cabinet, is the type. The specimen is in high relief upon coarse sandstone from South Hadley, Massachusetts. It occurs in association with *Otozoum moodii* and *Anchisauripus dananus*. It is also reported from New Jersey (figs. 12 and 13).

Grallator tenuis E. Hitchcock.

Grallator tenuis E. Hitchcock, '58, p. 73, pl. 13, fig. 4; pl. 53, fig. 5.

Specific characters. Divarication of digits II and III, 15° to 25° ; of III and IV, 25° to 28° ; of II and IV, 40° to 45° . Length of digit II, .030 m.; of III, .049 m.; of IV, .045 m. Length of foot, .073 m. Distance between lateral tips, .037 m. Length of step, .195 m. Width of trackway, .063 m.

The chief distinctions between this form and *G. cursorius*

are the shorter stride and greater divarication of the toes of the present species. Both of these are variable quantities and future research may prove the species to be synonymous in which case *G. cursorius* would have priority.

The type specimens are nos. $\frac{12}{3}$ and $\frac{12}{4}$, of the Hitchcock cabinet, counterparts, from Turner's Falls, Massachusetts. The slabs are red shale and were found in close proximity to the trap. The figured specimen is no. $\frac{17}{4}$, of the Hitchcock cabinet (fig. 14). The species is also reported from Connecticut and New Jersey.

Grallator cuneatus E. Hitchcock.

Grallator cuneatus E. Hitchcock, '58, p. 74, pl. 13, fig. 6; pl. 39, figs. 1, 3; pl. 41, fig. 1-2.

Specific characters. Divarication of digits II and III, 23° ; of III and IV, 23° ; of II and IV, 46° . Length of

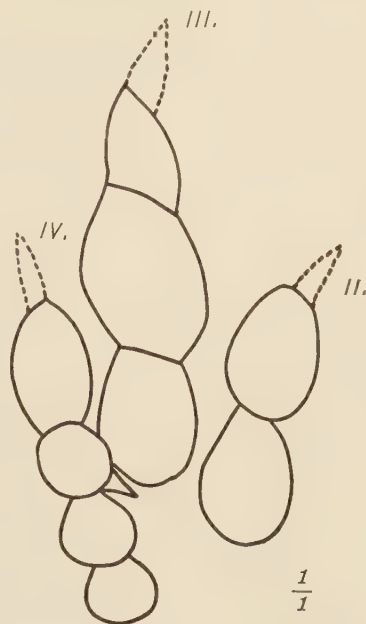


Fig. 13. *Grallator cursorius* E. Hitchcock. Impression of the left pes. $\times \frac{1}{1}$. From no. $\frac{9}{8}$, of the Hitchcock cabinet.

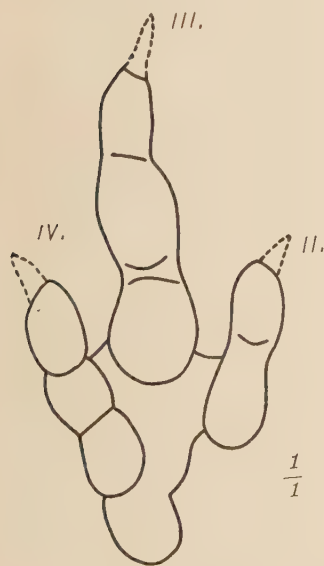


Fig. 14. *Grallator tenuis* E. Hitchcock. Track of the left pes. $\times \frac{1}{1}$. From no. $\frac{17}{4}$, of the Hitchcock cabinet.

digit II, .063 m.; of III, .081 m.; of IV, .074 m. Distance between lateral tips, .080 m.

Length of foot, .125 m. Length of step, .460 to .550 m. Width of trackway, .090 m.

This form, while a true *Grallator*, is quite similar to *Anchisauripus dananus*, but is distinguished from the latter by the greater projection of the middle toe and the generally cuneiform shape of the foot which is heightened by the bending outward of the lateral claws.

The type is no. $\frac{25}{1}$, of the Hitchcock cabinet, on red shale from the Lily pond at Turner's Falls, Massachusetts. Figured specimen, no. $\frac{17}{1}$, of the Hitchcock cabinet, from Turner's Falls (fig. 15).

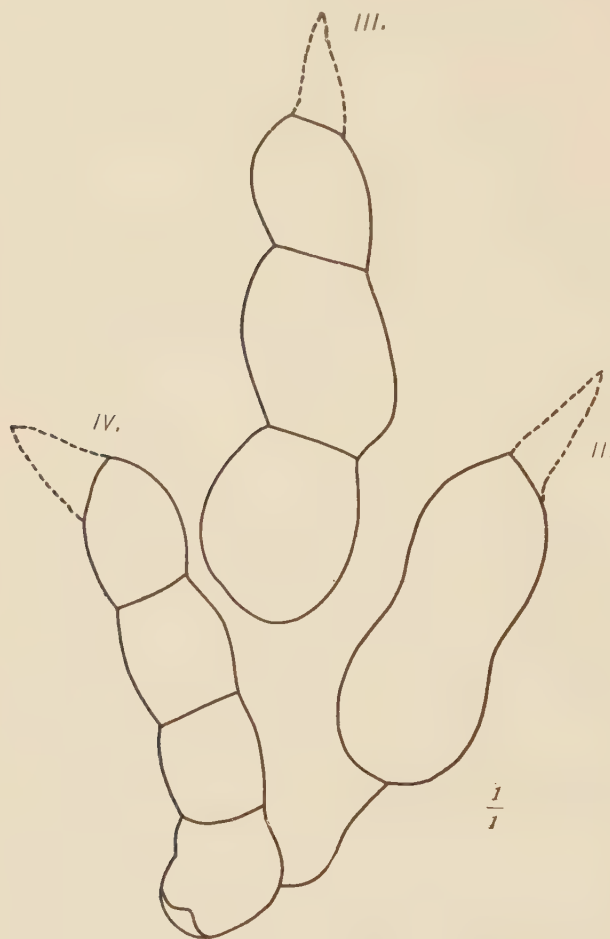


Fig. 15. *Grallator cuneatus* E. Hitchcock. Impression of the left pes. $\times \frac{1}{1}$. From no. $\frac{17}{1}$, of the Hitchcock cabinet.

***Grallator formosus* E. Hitchcock.**

Grallator formosus E. Hitchcock, '58, p. 75, text fig. 1 on p. 77.

Specific characters. Divarication of digits II and III, 11.5° ; of III and IV, 21.5° ; of II and IV, 33° . Length of digit II, .075 m.; of III, .118 m.; of IV, .114 m. Distance between lateral tips, .110 m. Projection of middle toe

beyond the lateral ones, .070 m. Length of foot, .172 m. Length of step, .655 m.

This is very large for a *Grallator*, but is long of limb and lacks a hallux on all known specimens. It resembles *G. cuneatus*, differing from the latter chiefly in size. It approaches very near *Anchisauripus dananus* and may prove to be identical at any rate with some of the specimens referred to that species.

Type specimen, no. $\frac{3}{1}$, of the Hitchcock cabinet, shale from South Hadley, Massachusetts (fig. 16), associated with *Otozoum moodii*.

***Grallator gracilis* C. H. Hitchcock.**

Grallator gracilis C. H. Hitchcock, in E. Hitchcock, '65, p. 8, pl. 9, fig. 7.

Specific characters. Divarication of digits II and III, 22° to 23° ; of III and IV, 14°

to 16° ; of II and IV, 35° to 40° . Length of digit II, .026 m.; of III, .035 m.; of IV, .030 m. Distance between lateral tips, .027 m. Length of foot, .045 m. Projection of middle toe beyond the lateral ones, .017 m. Length of step, .315 m.

Charles Hitchcock's character of the non-extension of the inner toe so far as the outer one seems to be inconstant for they are about equal in extent in the present author's figure, from no. $\frac{23}{8}$ (Hitchcock cabinet). This, one of the most diminutive of dinosaur tracks, represents a foot about two thirds the length of that of *Compsoognathus* of the lower Kimeridgian limestone of Bavaria, the smallest known form.

The type is no. $\frac{17}{2}$, of the Hitchcock cabinet, on red shale from Turner's Falls, Massachusetts, and the figured specimen is no. $\frac{23}{8}$ from the same locality (fig. 17). The species is reported from Massachusetts and New Jersey.

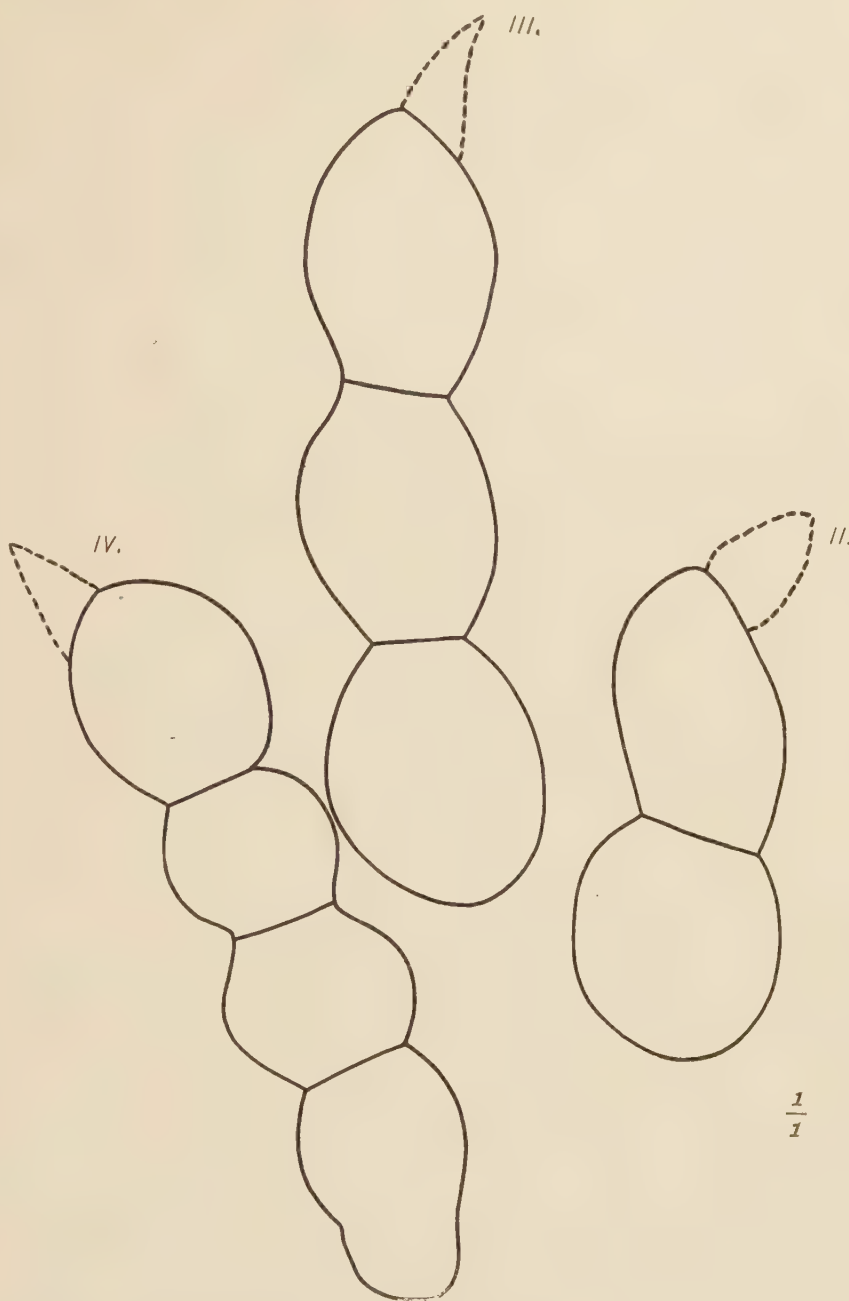


Fig. 16. *Grallator formosus* E. Hitchcock. Imprint of the left pes. $\times \frac{1}{1}$. From the type specimen, no. $\frac{3}{1}$, of the Hitchcock cabinet.

Genus **Stenonyx** nom. nov. (Narrow claw.)

Leptonyx E. Hitchcock, '65, p. 8 (name preoccupied).

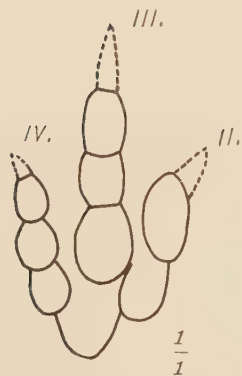


Fig. 17. *Grallator gracilis* E. Hitchcock. Impression of the left pes. $\times \frac{1}{4}$. From no. $\frac{23}{8}$, of the Hitchcock cabinet.

Generic characters. Bipedal, tridactyl, digitigrade track, very minute. With thick toes and long slender claws and distinct phalangeal pads. Length of limb unknown as the genus is known only from two isolated tracks. There is no tail trace.

Stenonyx lateralis (E. Hitchcock).

Leptonyx lateralis E. Hitchcock, '65, p. 8, pl. 5, fig. 3.

Specific characters. Divarication of digits II and III, 32° ; of III and IV, 28° ; of II and IV, 60° . Length of digit II, .015 m.; of III, .021 m.; of IV, .021 m. Distance between lateral tips, .021 m. Length of foot, .030 m.

This species seems to approach most nearly to *Grallator gracilis* but is much smaller, and has more slender claws which arise from the median side of digits II and III and from the outside of digit IV; hence the specific name.

Type, no. $\frac{47}{40}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Genus **Selenichnus** E. Hitchcock. (Moon track.)

Selenichnus E. Hitchcock, '58, p. 133.

Generic characters. Bipedal, tridactylous. Inner toe rarely distinct. A continuous caudal trace, but slightly sinuous. Tracks nearly in line and without pads or claws.

Selenichnus falcatus E. Hitchcock.

Selenichnus falcatus E. Hitchcock, '58, p. 133, pl. 23, fig. 8; pl. 60, fig. 8.

Specific characters. Pes: divarication of digits cannot be measured. Length of digits from extremity of the heel: of II, .036 m.; of III, .072 m.; of IV, .056 m. Length of foot, .072 m. Width of foot, .018 m. Length of step, .090 m. The feet turn outward so that the heels are in line, the tail trace usually passing through them. The toes curve inward.

This is a very striking track and though obscure as to details is readily recognizable. It was apparently formed by a small dinosaur of unknown affinities.

Type specimens are nos. $\frac{42}{6}$ and $\frac{42}{7}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Selenichnus brevisculus E. Hitchcock.

Selenichnus brevisculus E. Hitchcock, '58, p. 134, pl. 23, fig. 9; pl. 60, fig. 7.

Specific characters. Pes: length of foot, .046 m.; length of step, .058 m. Width of trackway, .038 m.

This form is found at Turner's Falls, Massachusetts, associated with *S. falcatus* and as Hitchcock says, "may be the young of that species."

Type, no. $\frac{44}{10}$, of the Hitchcock cabinet, a beautiful slab of twenty-three tracks passing in a curved line across the surface.

Order *ORTHOPODA* Cope. (*Predentata* Marsh.)

Ordinal characters. Bipedal dinosaurs, with a mesaxonic, generally digitigrade, tetradactyl or tridactyl foot, armed with more or less blunted claws. The foot ranges from the plantigrade, functionally tetradactyl type of *Otozoum*, through the digitigrade (occasionally calcigrade while resting) and functionally tridactyl pes of *Anomoepus*, to the digitigrade, probably structurally tridactyl pes of *Eubrontes*. The manus is pentadactyl with blunt claws and, while occasionally touching the ground in the resting position, is never used for locomotion; it is considerably smaller than the pes. A caudal trace is occasionally present in some genera.

Family **ANOMOEPODIDAE**.

Family characters. Bipedal in gait, the manus impressing only when resting. Pes tetradactyl, digitigrade with elongate metatarsal segment upon which the animal sits (calcigrade) while at rest. Hallux half rotated, insistent, and subfunctional, but rarely impressing. Pes ornithoid.

Manus pentadactyl, the digits ranging through an angle of 180°. Phalangeal formula: 2. 3. 4. 3. 2. Claws bluntly rounded.

The proportions, except for the elongated metatarsals, and the conformation of the feet and claws, seem to correlate this group with the Wealden predentate dinosaur, *Hypsilophodon*, which, because of its toothed premaxillary, the generalized character of the teeth and other reasons, Osborn¹ believes to represent the Triassic Orthopoda more nearly than any other known form. There are at least two genera which exhibit all of the family characters and others which are evidently nearly related. Genera: *Anomoepus*, *Fulicopus*, *Apatichnus*; possibly *Corvipes*, and others.

¹ Osborn, Columbia university lectures, 1903.

Genus **Anomoepus** E. Hitchcock. (Unlike foot.)

Anomoepus E. Hitchcock, '48, p. 220.

Generic characters. In addition to the family characters above mentioned, this genus may be readily recognized by its very characteristic foot in which the toes are quite widely divergent, especially digit IV. There is also a doubling of many of the lines over the articulations of the phalanges similar in appearance to those of the human hand. Limbs only moderately long; when resting, considerable weight is borne on the hand, a point of difference with the succeeding genus. There is an occasional tail trace and ischial callosity impression. There is also a pad on the sole of the foot in line with and in

addition to the four which are usually found on digit IV. The type species is *A. scambus* E. Hitchcock.

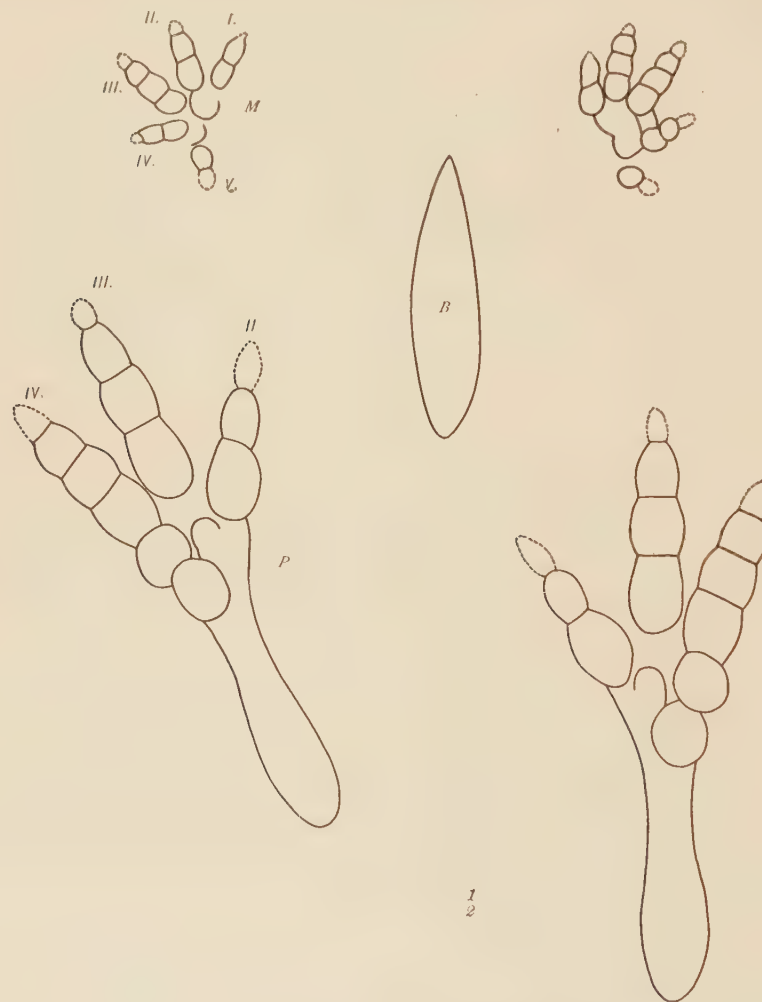


Fig. 18. *Anomoepus scambus* E. Hitchcock. Impression of all four feet of a seated individual. $\times \frac{1}{2}$. B, impression of the breast; M, manus; P, pes. Drawn from no. $\frac{1}{5}$, of the Hitchcock cabinet. The manus is restored in outline after Deane.

Anomoepus scambus

E. Hitchcock.

Anomoepus scambus E. Hitchcock, '48, p. 222, pl. 13, fig. 1-6.

Anomoepus minor E. Hitchcock, '58, p. 57, pl. 9, fig. 1-2; pl. 34, fig. 2.

Specific characters. Pes: digit I, unknown. Divarication of digits II and III, 20° to 35° ; of III and IV, 22° to 23° . Length of digit II, .049 to .057 m.; of III, .060 to .080 m.; of IV, .063 to .083 m. Length of foot, .095 m.; with the heel, .168 to .210 m.

Manus: divarication of digits I and II, 17.5° to 43° , a great variation, in-

dicating a versatile pollex; of digits II and III, 22° to 29° ; of III and IV, 24° to 50° ; of IV and V, 55° to 87° ; of I and V, 120° to 152° . Length of digit I, .024 m.; of II, .029 m.; of III, .032 m.; of IV, .024 m.; of V, .015 m. Length of step, .230 m. Width of trackway, .200 m.

Although it is the type species, *Anomoepus scambus* is of comparatively rare occurrence so that in the present memoir the morphological studies were made upon *A. intermedius*, perhaps the most abundant form. The figure (fig. 18) was studied from no. $\frac{16}{5}$, of the Hitchcock cabinet, together with no. $\frac{34}{40}$ and the drawing in Deane ('61, pl. 32). The last is from a magnificent specimen formerly owned by T. Leonard, Esq., of Greenfield, Massachusetts, and at present lost sight of. An interesting feature occurs on no. $\frac{34}{40}$, viz., the somewhat lenticular impression of the breast of the animal possibly made by a plastron-like armature.

Types, nos. $\frac{16}{5}$ and $\frac{34}{40}$, of the Hitchcock cabinet, on red shale, the latter from Turner's Falls, Massachusetts.

***Anomoepus intermedius* E. Hitchcock.**

Anomoepus intermedius E. Hitchcock, '65, pp. 2 and 7, pl. 1, fig. 1; pl. 15, fig. 1. This species is based upon part of *Brontozoum isodactylum* E. Hitchcock, '58, p. 69. Here also probably belong the following species:—

Sauropus barrattii E. Hitchcock, '45b, p. 24.

Aethiopus minor E. Hitchcock, '58, p. 69 (in part).

Plesiornis quadrupes E. Hitchcock, '58, p. 102, pl. 17, fig. 7; pl. 35, fig. 1–2; pl. 55, fig. 5.

Plectropterna minitans E. Hitchcock, '58, p. 108.

Apatichnus holyokensis C. H. Hitchcock, '89b, pp. 118, 123, 124.

Specific characters. Pes: divarication of digits I and II, 56° ; of II and III, 20° ; of III and IV, 35° ; of I and IV, 110° or more. Length of digit II, .052 m.; of III, .073 m.; of IV, .057 m. Length of foot, .105 m.; including the heel, .173 m.

Manus: divarication of digits I and II, 33° ; of II and III, 22° ; of III and IV, 68° ; of IV and V, but little, as they are nearly parallel. Length of digit I, .015 m.; of II, .028 m.; of III, .030 m.; of IV, .023 m. Length of step varies in the same animal from .140 to .235 m., the average being about .220 m. Width of trackway, .150 to .180 m.

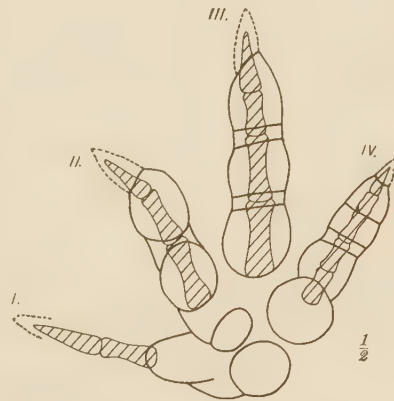


Fig. 19. *Anomoepus intermedius* E. Hitchcock. Impression of the right pes of a walking animal, with the bones restored. $\times \frac{1}{2}$. From the type specimen, no. $\frac{48}{1}$, of the Hitchcock cabinet.

This form differs from *A. scambus* in the greater divarication of the lateral digits

and the greater relative stoutness of the foot in proportion to its length, and especially in the relatively shorter heel. An exceedingly interesting series of tracks is shown on slab no. $\frac{48}{1}$, of the Hitchcock cabinet, containing at least fifty impressions, all but four being of this species. Here the animal is shown walking, then stopping and sitting down, then rising and going on again. No caudal trace is exhibited until just before stopping, showing that ordinarily the tail was used as a counterpoise, only reaching the ground while the creature assumed the quadrupedal posture or just before. The impression of the ischial callosity is also to be seen. The difference in the character of the foot impression in the walking and sitting form is well shown and is brought out in figures 19 and 20, which are drawn from the slab in question.

The type specimen is no. $\frac{48}{1}$ mentioned above, reddish sandstone from Turner's Falls, Massachusetts; figured in E.

Hitchcock ('65, pl. 15, fig. 1). Figure 21 is from slabs nos. $\frac{54}{13}$ and $\frac{52}{4}$. The latter specimen C. H. Hitch-

Fig. 20. *Anomoepus intermedius* E. Hitchcock. Tracks of the right manus and pes of a seated individual, probably identical with the one which made the track shown in figure 19. $\times \frac{1}{2}$. From the type slab, no. $\frac{48}{1}$, of the Hitchcock cabinet. The skeleton restoration shows the metatarsals and phalanges.

cock recognizes as being *Apatichnus holyokensis* (*vide supra*).

***Anomoepus curvatus* E. Hitchcock.**

Anomoepus curvatus E. Hitchcock, '65, p. 5, pl. 1, fig. 2; pl. 15, fig. 2.

Specific characters. Pes: divarication of digits I and II, 40° ; of II and III, 23.5° ; of III and IV, 36.5° . Length of digit II, .050 m.; of III, .064 m.; of IV, exclusive of sole pad, .055 m. Length of foot, .098 m. The heel and manus are unknown. Length of step, .230 to .250 m.

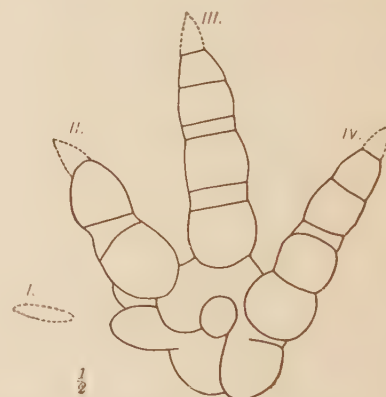
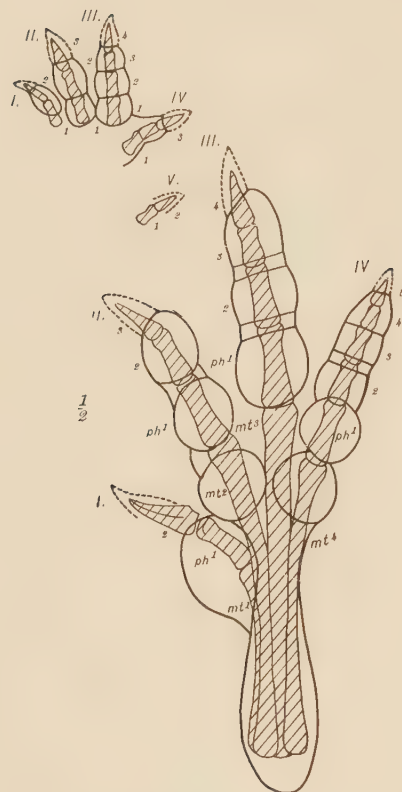


Fig. 21. *Anomoepus intermedius* E. Hitchcock. Impression of right pes. $\times \frac{1}{2}$. A composite drawing from nos. $\frac{54}{13}$ and $\frac{52}{4}$, of the Hitchcock cabinet.

The species *curvatus* approximates *intermedius* very closely, being distinguished chiefly by its smaller size, by the lesser divergence of the outer toe, and by the distinct inward curvature of the middle toe which is present, though to a less degree, in the fourth toe.

The type specimen is no. $\frac{52}{10}$, of the Hitchcock cabinet, a photograph of which may be seen in E. Hitchcock ('65, pl. 15, fig. 2). This specimen is from Lily pond, at Turner's Falls, Massachusetts (fig. 22).

Anomoepus crassus (C. H. Hitchcock).

Apatichnus crassus C. H. Hitchcock, '89b, pp. 118, 122, 124.

Specific characters. Pes: divarication of digits I and II, 80° ; of II and III, 32° ; of III and IV, 40° ; of II and IV, 72° . Length of digit II, .085 m.; of III, .102 m.; of IV, not including the sole pad, .083 m.; including the sole pad, .120 m. Length of foot, .190 m. Distance between lateral tips, .140 m. Length of step, .387 m.

Manus: width of impression, .060 m.; length, .060 m.

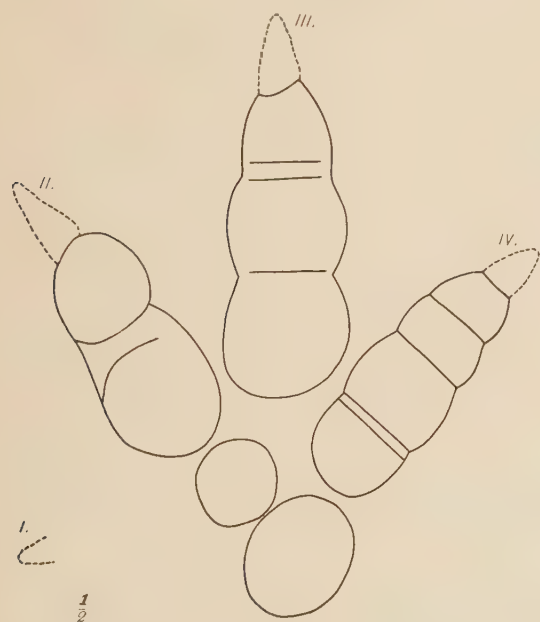


Fig. 23. *Anomoepus crassus* C. H. Hitchcock. Imprint of right pes. $\times \frac{1}{2}$. From the type specimen in the museum of Rutgers college.

m.; of III, .050 m.; of IV, .033 m. Length of foot, .054 m. Heel unknown.

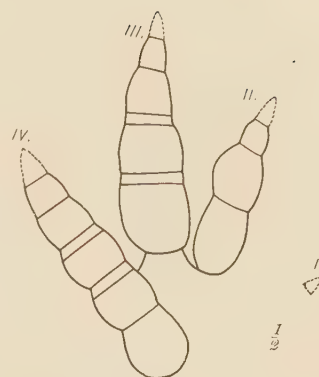


Fig. 22. *Anomoepus curvatus* E. Hitchcock. Imprint of left pes. $\times \frac{1}{2}$. From the type specimen, no. $\frac{52}{10}$, of the Hitchcock cabinet.

The foot of *A. crassus* resembles that of *A. intermedius* in general form but is considerably larger and the hallux is rotated backward to a greater extent than in the latter form. *A. crassus* is reported only from New Jersey, the type specimen, which is preserved in the museum of Rutgers college, being from Whitehall, near Boonton, in that state (fig. 23).

Anomoepus minimus E. Hitchcock.

Anomoepus minimus E. Hitchcock, '65, p. 5, pl. 2, fig. 2.

Specific characters. Pes: divarication of digits II and III, 40° ; of III and IV, 35° . The hallux does not appear on the type specimen. The length of digit II is .035

Manus: divarication of digits I and II, 40° ; of II and III, 25° ; of III and IV, 48° ; of IV and V, 28° . Length of digit I, .012 m.; of II, .014 m.; of III, .021 m.; of IV, .014 m.; of V, .010 m. Length of step, .170 to .210 m. Width of trackway, .076 m.

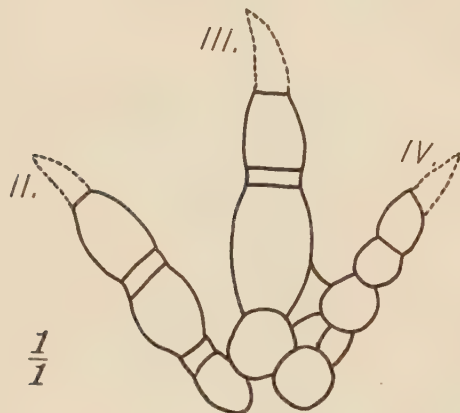


Fig. 24. *Anomoepus minimus* E. Hitchcock. Impressions of the right manus and pes. $\times \frac{1}{1}$. A composite figure from the type specimen, no. $\frac{5.5}{112}$ and no. $\frac{5.5}{112}$ of the Hitchcock cabinet.

This species is readily distinguishable from all but the next succeeding species, by its small size and delicate proportions.

The type is no. $\frac{5.5}{112}$, of the Hitchcock cabinet, from Gill, Massachusetts, and is here shown (fig. 24).

***Anomoepus gracillimus* (E. Hitchcock).**

Eubrontes gracillimus E. Hitchcock, '45b, p. 23.

Brontozoum gracillimum E. Hitchcock, '48, p. 175.

Grallator gracillimus E. Hitchcock, '58, p. 73, pl. 13, fig. 5; pl. 39, fig. 2.

Anomoepus gracillimus C. H. Hitchcock, in E. Hitchcock, '65, p. 6.

Specific characters. Pes: divarication of digits II and III, 28° ; of III and IV, 23° . Length of digit II, .039 m.; of III, .050 m.; of IV, .046 m. Length of foot, .064 m. Length of step, .180 to .200 m. Width of trackway, .090 m.

This form was removed from *Grallator* by C. H. Hitchcock, with the acquiescence of his father, on the following grounds: "First, the short stride of the animal; second, the thick, *Anomoepus* type of the foot; and third, the occasional presence of a long heel upon the hind foot." It differs from *A. minimus* chiefly in the much less divarication of the toes.

The type is no. $\frac{5.0}{1}$, of the Hitchcock cabinet, on red sandstone from Turner's Falls, Massachusetts.

***Anomoepus cuneatus* C. H. Hitchcock.**

Anomoepus cuneatus C. H. Hitchcock, '89b, pp. 118, 125.

Specific characters. Pes: divarication of digits II and IV, 40° . Length of step, .330 to .460 m. Width of trackway, .178 m. "Long and distinct impression made by the

middle toe and also by a slender tail. Like *Grallator cuneatus*. Shorter stride and length of step would seem to ally it with *Anomoepus*." These reasons, as given by Hitchcock, are valid as far as they go, but further study seems necessary to decide without question the true position of this form.

The type specimen is no. 105 of the Mt. Holyoke museum.

***Anomoepus isodactylus* C. H. Hitchcock.**

Anomoepus isodactylus C. H. Hitchcock, '89b, pp. 118, 124.

Specific characters. Pes: divarication of digits I and II, 50°; of II and III, 29°; of III and IV, 30°. Length of hallux, .043 m.; of digit II, .043 m.; of III, .072 m.; of IV, including the sole pad, .101 m. Average width of phalanges, .025 m. Length of foot, .115 m.; including the heel, .230 m. The basal pads of the hallux, as well as the claw, impress, showing that toe to be incumbent. Manus: unknown. Length of step, .205 m.

This species is based upon specimens in the Mt. Holyoke museum, but of the specimens labeled *A. isodactylus*, one is clearly *A. intermedius*, while the others, no. 128 and its counterpart no. 142, are the ones used for this description, the figure (fig. 25) being drawn from the former. Another slab in the northeast corner of the museum, and bearing no number, has the impression of the sitting animal of this species. This form resembles somewhat superficially *A. intermedius*, but is a heavier, broader toed animal, with a foot very short in proportion to its width.

Type specimens, nos. 128 and 142, of the Mt. Holyoke museum, from South Hadley, Massachusetts.

Genus **Fulicopus** E. Hitchcock. (Fulica foot.)

Fulicopus E. Hitchcock, '45b, p. 23.

Anomoepus E. Hitchcock, '58, p. 56 (in part).

Generic characters. The members of this genus are distinguished from *Anomoepus* by the greater size, especially of the pes, less acuminate claws, and the absence of the sole pad in addition to the four normally belonging to digit IV. An ischial callosity may also be present. The track of the pes shows less divarication of the toes than does that of *Anomoepus* and in general appearance resembles

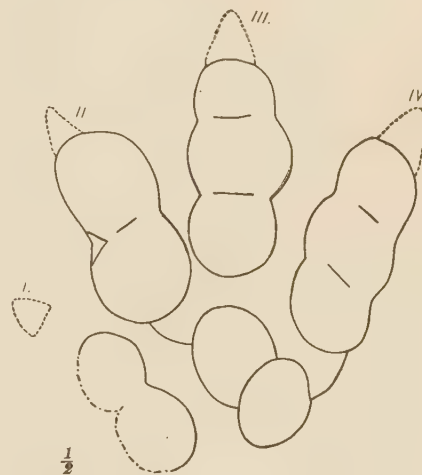


Fig. 25. *Anomoepus isodactylus* C. H. Hitchcock. Imprint of the right pes. $\times \frac{1}{2}$. From the type specimen, no. 128, of the Mt. Holyoke college collection.

Eubrontes very closely. It is distinguished from Eubrontes, however, by the presence of the heel and the partly rotated hallux. When the animal is walking and these two characters are not seen it is very difficult to distinguish the two genera.



Fig. 26. *Fulicopus lyellianus* E. Hitchcock. Impressions of the right manus and pes of a seated individual. $\times \frac{1}{4}$. From the type specimen (*Anomoepus major*), no. $\frac{1}{4}$, of the Hitchcock cabinet.

The posture of the animal is somewhat different from that of *Anomoepus* for here the creature brings the hind limbs more under the body so that very little weight is borne on the hands as in the kangaroo. This makes a very light and incomplete manus impression, no pads being discernible. The claws are more slender in proportion to the width of the fingers than in *Anomoepus*, probably correlated with their slight use as supporting organs and consequent greater prehensile function.

***Fulicopus lyellianus* E. Hitchcock.**

Fulicopus lyellianus E. Hitchcock, '45b, p. 23.

Aethyopus lyellianus E. Hitchcock, '48, p. 178.

Anomoepus major E. Hitchcock, '58, p. 56, pl. 8.

Amblonyx lyellianus E. Hitchcock, '58, p. 71, pl. 13, fig. 2; pl. 37, fig. 2.

Specific characters. Pes: divarication of digits I and II, 40° ; of II and III, 11.5° ; of III and IV, 14° . Length of digit I, .083 m.; of II, .103 m.; of III, .147 m.; of IV, .156 m. Length of foot, .220 m.; of foot and heel, .427 m. Breadth of heel, .050 m. Distance between lateral tips, .110 m.

Manus: divarication of digits I and II, 6° ; of II and III, 32° ; of III and IV, 20° ; of IV and V, 26° . Length of digit I, .031 m.; of II, .038 m.; of III, .040 m.; of IV, .033 m.; of V, .020 m. Length of step, .765 m. Width of trackway, .127 m. Length of ischial callosity, .055 m.; width, .060 m.

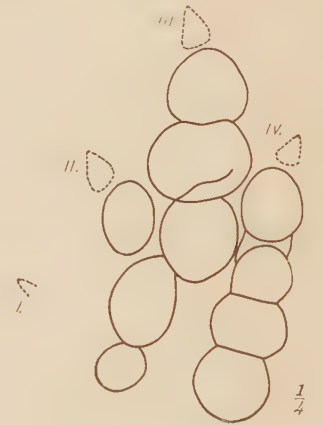


Fig. 27. *Fulicopus lyellianus* E. Hitchcock. Imprint of the right pes of a walking individual, identical with the one that made the impressions shown in figure 28. $\times \frac{1}{4}$. From the type track, on slab no. $\frac{1}{4}$, of the Hitchcock cabinet.

The type specimens of *Fulicopus lyellianus*, nos. $\frac{1}{1}$ and $\frac{31}{85}$, of the Hitchcock cabinet, are referable to *Anomoepus major*, being identical in form and size with the latter after allowing for such changes as the shifting of the animal's weight from the heel to the whole foot while walking, would make, especially in the posterior pads. The specimen of *F. lyellianus* on slab no. $\frac{1}{1}$ on which the type of *A. major* is also found, is so similar to the latter as to lead to the belief that they were made by the same individual. This belief is increased by the occurrence of certain unique markings upon both tracks which are brought out in the figures. This seems to prove the synonymy of the two species

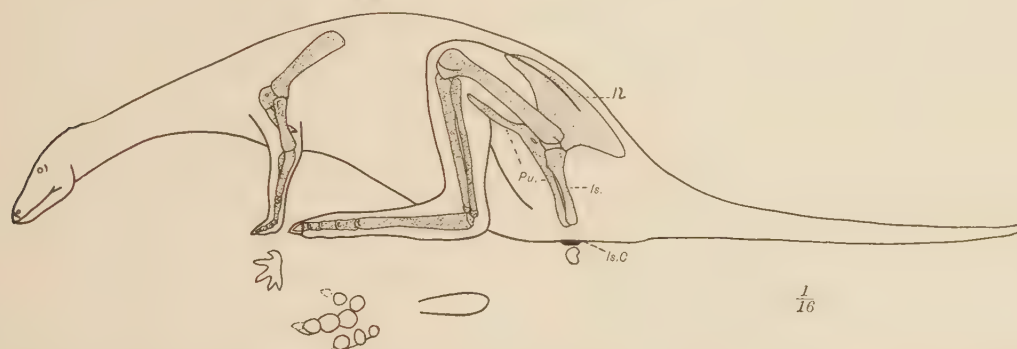


Fig. 28. *Fulicopus lyellianus* E. Hitchcock. Restoration of the dinosaur in the attitude of feeding. $\times \frac{1}{16}$. Based upon the footprints figured above (fig. 26). The general contour and the bones are suggested by Marsh's figured restoration of *Hypsilophodon*, although the proportions of the limb segments are altered. The lateral digits of manus and pes are omitted for clearness. Il., ilium; Is., ischial bones; Is. C., ischial callosity; Pu., pubic bones.

(compare figures 26 and 27). *Fulicopus lyellianus* as a name should have priority and must be used though the generic name was founded upon a misconception. The other species of the genus, *Fulicopus giganteus*, is referred to *Eubrontes* under the specific name *platypus* as there is a *giganteus* already in the genus.

The peculiar heart-shaped impression shown in figure 28 (see also E. Hitchcock, '65, pl. 19) behind and between the heels, already alluded to as that of the ischial callosity, is attributed by E. Hitchcock ('58, p. 56) to the end of a truncated tail. The paired ends of the ischial bones upon which the Orthopoda rested, would come at just about the position indicated by the mark in question, and while the bones themselves could not have made the impression, a callosity such as the sternal callosity seen in the dromedary, is not out of the question and seems the most likely explanation that can be given.¹ Figure 28 attempts to show the animal seated as though drinking and demonstrates this idea.

In the type specimen of *Anomoepus intermedius*, no. $\frac{48}{1}$, of the Hitchcock cabinet,

¹ The possibility of a callosity being present was suggested to the author by Mr. Charles R. Knight, though the conception of the posture together with the restoration are the writer's own.

impressions both of the tail and of the ischial callosity of the same individual may be seen, the difference in the two marks being such that they could not have been made by the same organ, the former being a narrow groove while the latter is a broad rounded depression.

The type specimens are nos. $\frac{1}{1}$ and $\frac{1}{7}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Genus **Apatichnus** E. Hitchcock. (Deceptive track.)

Apatichnus E. Hitchcock, '58, p. 99.

Generic characters. Bipedal in gait, digitigrade, functionally tridactyl. Claws on the pes are acuminate and the proximal pad of digit IV is very small. There is a caudal trace.

The distinction between this genus and *Anomoepus* was supposed to be the presence of a hallux in the present group and its absence in the other. It has been found in both genera thus removing several of the species from *Apatichnus* to *Anomoepus* as they were clearly of the latter type but were known to possess the hallux.

Apatichnus, of which *A. circumagens* is the type, differs from *Anomoepus* in the much shorter hallux and in the fact that, while the divarication between digits II and III is less, that between III and IV is much greater, giving to the middle digit the appearance of being exserted far beyond the others, a point which is well brought out in the figures.

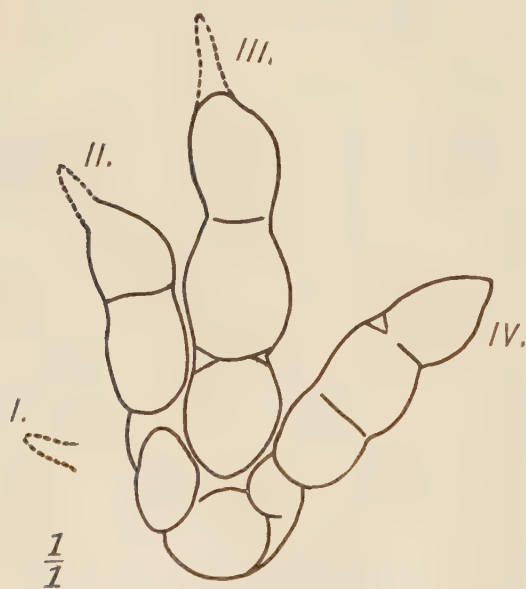


Fig. 29. *Apatichnus circumagens* E. Hitchcock. Impression of right pes. $\times \frac{1}{1}$. From no. $\frac{23}{8}$, of the Hitchcock cabinet.

Apatichnus circumagens E. Hitchcock.

Apatichnus circumagens E. Hitchcock, '58, p. 100, pl. 17, fig. 5; pl. 35, fig. 6.

Specific characters. Pes: divarication of digits I and II, 53° ; of II and III, 18° ; of III and IV, 46° ; of I and IV, 116° . Length of digit I, .025 m.; of II, .035 m.; of III, .062 m.; of IV, .053 m. Length of foot, .075 m. These measurements are taken from no. $\frac{23}{8}$, the figured specimen; those of Hitchcock, from no. $\frac{21}{2}$, are somewhat larger and the angle of divarication of digits II and III is greater.

Hitchcock gives the length of the entire foot and heel as .127 m., the foot alone being half that length. The average length of step is .240 m.

Manus: turned inward toward the median line. Caudal trace sinuous, not always present.

Type specimen, no. $\frac{21}{2}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts. Figured specimen, no. $\frac{23}{8}$, on red micaceous sandstone from the Ferry at Turner's Falls, Massachusetts (fig. 29).

Apatichnus minus (E. Hitchcock).

Gigantitherium minus E. Hitchcock, '58, p. 95, pl. 17, fig. 1; pl. 41, fig. 2; pl. 42, fig. 2.

Specific characters. Pes: divarication of digits II and III, 20° ; of III and IV, 43.5° . Length of digit II, .108 m.; of III, .147 m.; of IV, .146 m. Length of foot, .225 m. Distance between lateral tips, .160 m. Length of step, .630 m. Width of trackway, .167 m. Caudal trace straight, interrupted at each step. Manus: unknown.

This form was associated by Hitchcock with *Gigandipus caudatus*, though a far smaller species, but its affinities seem to be rather with *Apatichnus*, as it is evidently of the same type as *A. circumagens* (compare figures 29 and 30).

Type specimen, no. $\frac{1}{3}$, of the Hitchcock cabinet, on micaceous shale from Lily pond, Turner's Falls, Massachusetts (fig. 30).

Genus **Corvipes** E. Hitchcock. (Crow foot.)

Corvipes E. Hitchcock, '58, p. 98.

Generic characters. Quadrupedal. Pes tridactylous, ornithoid, digitigrade.

Manus pentadactylous, digits curved, position of print a little in advance of, sometimes without, again covered in part by that of the pes. No phalangeal nor claw impressions. Tips of digits more or less acuminate.

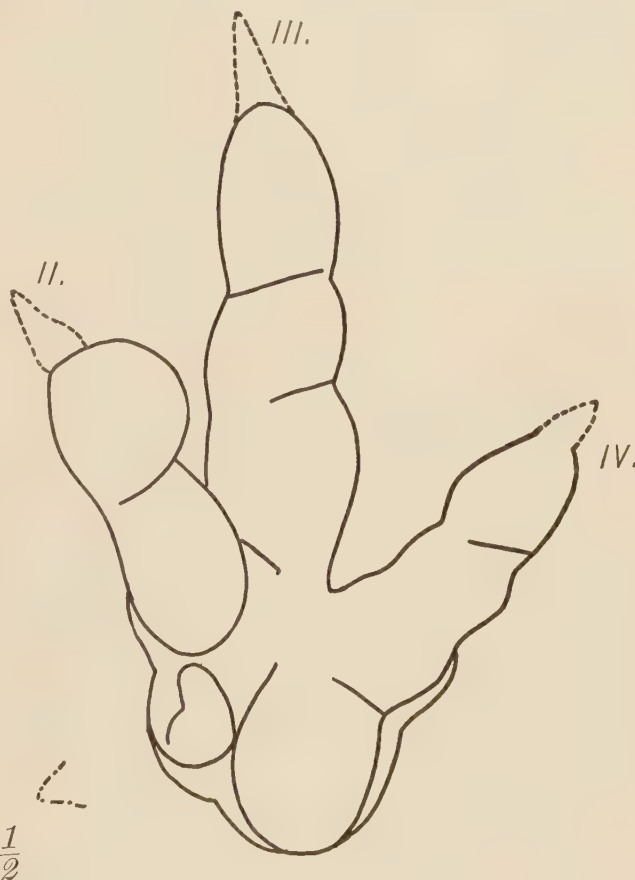


Fig. 30. *Apatichnus minus* E. Hitchcock. Imprint of the right pes. $\times \frac{1}{2}$. From the type specimen, no. $\frac{1}{3}$, of the Hitchcock cabinet.

Corvipes lacertoideus E. Hitchcock.

Corvipes lacertoideus E. Hitchcock, '58, p. 98, pl. 17, fig. 3; pl. 47, fig. 1; pl. 35, fig. 7.

Specific characters. Pes: divarication of digits II and III, 40°; of III and IV, 35°; of II and IV, 75°. Length of digit II, .033 m.; of III, .043 m.; of IV, .033 m. Length of heel, .023 m.; of the foot, .066 m. Length of step, .043 to .068 m.

Manus: divarication of digits I and V, 160°. Length of digit I, .010 m.; of II, .010 m.; of III, .019 m.; of IV, .020 m.; of V, .015 m.; of the hand, .033 m.

Type specimen, no. $\frac{32}{1}$, of the Hitchcock cabinet, on sandstone, from Turner's Falls, Massachusetts.

Family **EUBRONTIDAE**.

Family characters. Large bipedal forms, more or less rounded claws, digits broad with distinct phalangeal pads. Foot functionally, possibly structurally tridactyl as the hallux claw never impresses. No caudal trace.

Genus **Eubrontes** E. Hitchcock.

Eubrontes E. Hitchcock, '45b, p. 23.

Brontozoum E. Hitchcock, '47, p. 50.

Generic characters are those of the family. This genus is distinguished from *Anchisauripus* by the greater size, generally broader digits, and blunter claws, and by the absence of the hallux. A possible exception to the last point is seen in specimen no. $\frac{15}{1}$, of *E. giganteus*, from Northampton, Massachusetts, which is so deep that it will hold a gallon of water. This shows what seems to be the impression of a hallux claw in the same position to the rear as in the genus *Anchisauripus*, but the claw instead of being a prehensile one is more of the character of the anterior claws.

E. giganteus is the type species.

Eubrontes giganteus E. Hitchcock.

Eubrontes giganteus E. Hitchcock, '45b, p. 23.

Brontozoum giganteum E. Hitchcock, '47, p. 57; '58, p. 64, pl. 33, fig. 1-3; pl. 41, fig. 1; pl. 53, fig. 7; pl. 57, fig. 1.

Recharacterized by C. H. Hitchcock, in E. Hitchcock, '65, p. 23, pl. 10, fig. 1.

Specific characters. Divarication of digits II and III, 18°; of III and IV, 20°.

Length of digit II, .200 m.; of III, .260 m.; of IV, .285 m. Distance between lateral claws, .225 m. Length of foot, .370 m. Length of step, 1.090 to 1.170 m.

This form is the largest of the genus and with the possible exception of *Otozoum moodii* and *Gigandipus caudatus*, the largest of all the Connecticut valley dinosaurs. The track would indicate an animal eighteen to twenty feet in length and of massive build. Its occurrence is among the most frequent and it has been reported from Massachusetts, Connecticut, and New Jersey.

The type is no. $\frac{45}{8}$, of the Hitchcock cabinet, locality unrecorded. The figure (fig. 31) is drawn from no. $\frac{45}{1}$ of the same collection.

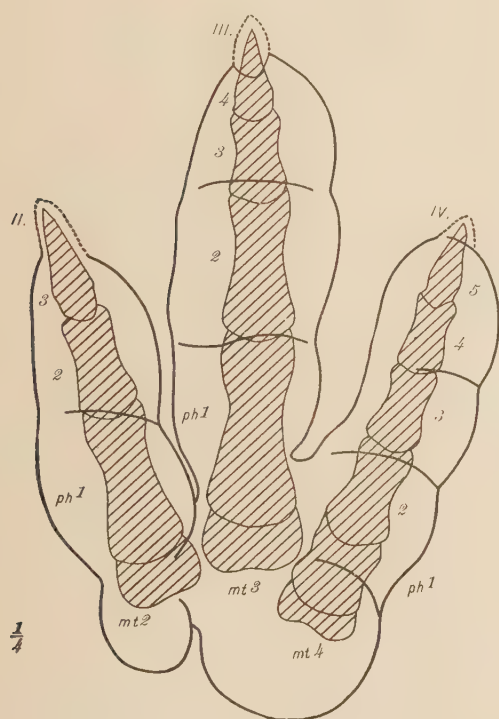


Fig. 31. *Eubrontes giganteus* E. Hitchcock. Impression of the right pes, with the skeleton of the foot restored. $\times \frac{1}{4}$. From no. $\frac{45}{1}$, of the Hitchcock cabinet.

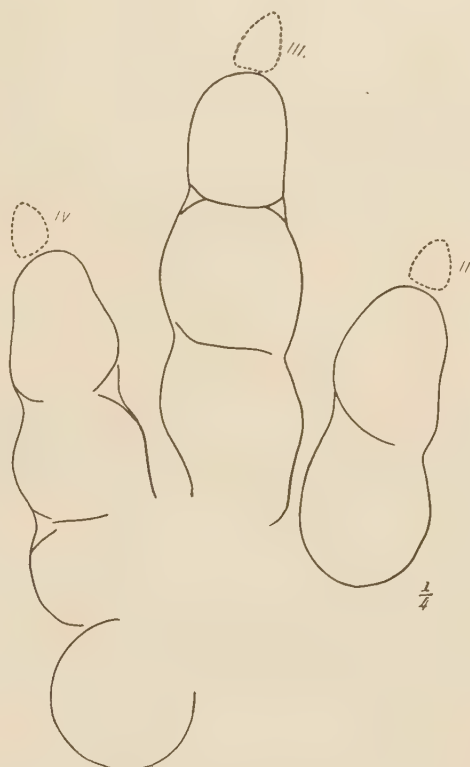


Fig. 32. *Eubrontes approximatus* (C. H. Hitchcock). Imprint of the left pes. $\times \frac{1}{4}$. From no. $\frac{32}{1}$, of the Hitchcock cabinet.

***Eubrontes approximatus* (C. H. Hitchcock).**

Brontozoum approximatum C. H. Hitchcock, in E. Hitchcock, '65, p. 23, pl. 10, fig. 2.

Specific characters. Divarication of digits II and III, 15° to 30° ; of III and IV, 13° to 24° . Length of digit II, .192 to .153 m.; of III, .274 to .230 m.; of IV, .308 to .295 m. Length of foot, .408 to .381 m. Length of step from no. $\frac{8}{1}$, .910 to 1.080 m. In the

above measurements the first given is from the figured specimen, no. $\frac{32}{51}$, the second from the type, no. $\frac{54}{10}$, of the Hitchcock cabinet.

This form is very near *E. giganteus* being distinguished therefrom mainly by its more slender proportions. The other distinguishing feature mentioned by C. H. Hitchcock, namely, that of the greater divarication of the toes, is not always apparent as the measurements show. The digits average .045 to .075 m. in width for *approximatus* as contrasted with .080 to .100 m. for *giganteus*.

Type, no. $\frac{54}{10}$, of the Hitchcock cabinet, on gray shale from Turner's Falls, Massachusetts. It is also reported from Connecticut and New Jersey (fig. 32).

Eubrontes divaricatus (E. Hitchcock).

Brontozoum divaricatum E. Hitchcock, '65, p. 7, pl. 4, fig. 1.

Specific characters. Divarication of digits II and III, 20° ; of III and IV, 35° to 50° . Length of digit II, .193 m.; of III, .243 m.; of IV, .262 m. Length of foot, .340 to .360 m. Length of step, 1.040 to 1.190 m.

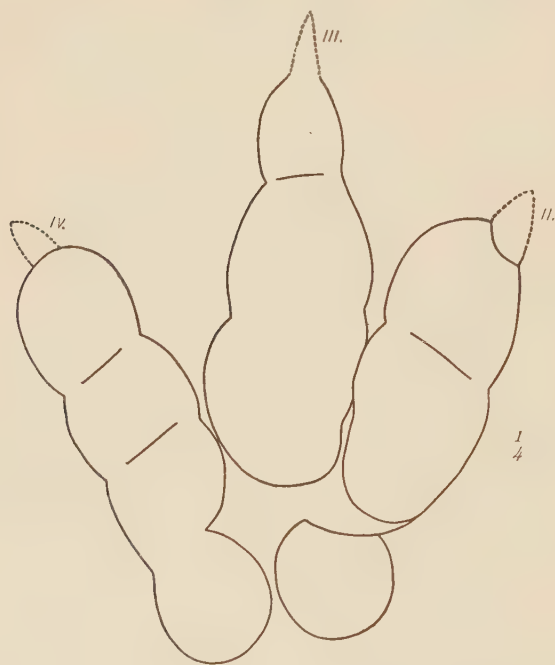


Fig. 33. *Eubrontes divaricatus* (E. Hitchcock). Impress of the left pes. $\times \frac{1}{4}$. Drawn from the type specimen, no. $\frac{58}{1}$, of the Hitchcock cabinet.

E. divaricatus is best shown in the type specimen, no. $\frac{58}{1}$ (fig. 33), which contains a row of four very deep tracks. It is distinguished, apart from size, by the decided divarication of the outer toe, a readily recognizable feature. In size it lies between *E. giganteus* on the one hand and *E. platypus* on the other.

The type, no. $\frac{58}{1}$, of the Hitchcock cabinet, is on hard shale, the locality being unrecorded.

Eubrontes platypus nom. nov.

Amblonyx giganteus E. Hitchcock, '58, p. 71, pl. 13, fig. 1; pl. 38, fig. 1-2; pl. 57, fig. 5.

Specific characters. Divarication of digits II and III, 12° ; of III and IV, 22° . Length of digit II, .157 m.; of III, .190 m.; of IV, .215 m. Distance between lateral claws, .190 m. Length of foot, .267 m. Length of step, 1.135 m. Very long limbed.

This species is revived although dropped by E. Hitchcock ('65, p. 2). The resemblance between it and *Anchisauripus tuberatus* is very close as regards size and general conformation, except that in the present species the phalangeal pads especially in the middle and outer digits, are much broader and the claws of all three toes are broad and blunted in contrast to the long, acuminate claw in *A. tuberatus*. The change of name was necessitated by the fact that the specific name *giganteus* was preoccupied in the genus.

Type, no. $\frac{13}{4}$, of the Hitchcock cabinet; red shale from Turner's Falls, Massachusetts (fig. 34).

Family **OTOZOIDAE**.

With the characters of the genus *Otozoum*.

Genus **Otozoum** E. Hitchcock. (Giant animal.)

Otozoum E. Hitchcock, '47, p. 54.

Generic characters. Large tracks, that of the pes being more than twice the length of the manus. Pes plantigrade, tetradactyl, all of the digits pointing forward. Digits broad with well marked phalangeal pads; claws rounded. The foot has a broad web-like flange extending beyond the tips of the toes, whose probable function was to support the animal in soft mud, possibly, however, for swimming. Manus pentadactyl. Phalangeal formula: (?) 2. 3. 3. 3. 3; digits III, IV, and V, clawed, fingers half webbed. This manus, if the interpretation be correct, is unique for a dinosaur and subsequent study may remove *Otozoum* from the order.

Otozoum moodii E. Hitchcock.

Otozoum moodii E. Hitchcock, '47, p. 55, fig. 1; '58, p. 123, pl. 22; pl. 23, fig. 1; pl. 33, fig. 4-5; pl. 46, fig. 5.

Specific characters. Pes: divarication of digits I and II, 25°; of II and III, 4°; of III and IV, 11°. Length of digit I, .196 m.; of II, .230 m.; of III, .192 m.; of IV, .202 m. Length of foot, .490 m.; to extremity of web, .534 m. Breadth of foot across web, .400 m.; distance between lateral tips, .380 m. (pl. 72, fig. F-G).

Manus: divarication of digits I and II, 53°; of II and III, 40°; of III and IV, 36.5°;

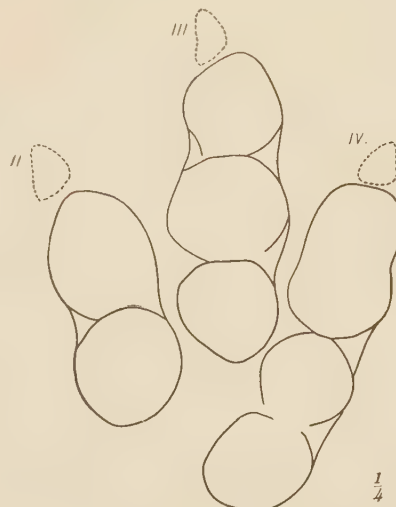


Fig. 34. *Eubrontes platypus* Lull. Imprint of the right pes. $\times \frac{1}{4}$. From the type specimen, no. $\frac{13}{4}$, of the Hitchcock cabinet.

of IV and V, 40° . Length of digit I, .056 m.; of II, .080 m.; of III, .092 m.; of IV, .098 m.; of V, .090 m. Length of foot, .206 m. (pl. 72, fig. E). Length of step, about .800 m.

The type specimen is no. $\frac{5}{14}$, of the Hitchcock cabinet, in high relief on coarse sandstone from South Hadley, Massachusetts. The counterpart, no. $\frac{3}{1}$, is taken some distance below the surface on which the animal walked as the layer of red mud which intervened was incapable of preservation.

The studies of the bone restoration of the pes are largely conventional and the results represent the most generalized dinosaurian foot which would be likely to be found in a bipedal dinosaur. The fifth digit is represented as vestigial. An accurate restoration of the manus skeleton will need the elucidation of further material. The genus *Otozoum* shows some extremely interesting parallelisms with the Stegocephalian genus *Chirotherium* which would lead one to suspect an actual relationship were it not for the fact that the phalangeal formula of the earlier form is such that that of *Otozoum* could never have been derived from it. The parallelisms and contrasts are:—

Chirotherium (pl. 72, fig. A–D).

Quadrupedal.
Pes pentadactyl.
Pads well developed.
Plantigrade.
Claws rounded.
Web extending beyond the toes.
Phalangeal formula: 2. 3. 4. 4. 2.
Manus pentadactyl.
Claws reduced.
Web as in pes.
Phalangeal formula: 2. 3. 3. 3. 3.
Hand pointing forward.

Habits apparently similar as the preservation of the tracks is the same in each instance. Relative length of the foot to the stride is the same.

Lower and upper Trias.
C. barthii. *C. storetonensis*.

Otozoum (pl. 72, fig. E–G).

Bipedal.
Pes tetradactyl.
Pads well developed.
Plantigrade.
Claws rounded.
Web extending beyond the toes.
Phalangeal formula: 2. 3. 4. 5. 0.
Manus pentadactyl.
Claws on II, III, and IV, developed.
Web reduced.
Phalangeal formula: 2. 3. 3. 3. 3.
Hand turned inward.

Jura-Trias.
O. moodii.

Otozoum caudatum C. H. Hitchcock.

Otozoum caudatum C. H. Hitchcock, '71, p. xxi; '89b, pp. 119, 127.

The present author seriously questions the validity of this species, which is distinguished from *O. moodii* only by the presence of a tail trace which could readily occur in

O. moodii provided the specimens showed the animal's track under favorable circumstances, that is, just before stopping. The other character, that of a forwardly directed "thumb" (hallux) as against a recurved one in *O. moodii* is hardly a valid distinction for the reason that the curvature is not a constant character, in fact it is of rare occurrence.

The type specimen of this species, if such it is, is in the museum of Wesleyan university, at Middletown, Connecticut.

? *Otozoum parvum* C. H. Hitchcock.

Otozoum parvum C. H. Hitchcock, '89b, pp. 119, 122, 127.

Specific characters. Pes: divarication of digits I and II, 24° ; of II and III, 16° ; of III and IV, 14° ; of I and IV, 54° . Length of digit I, .076 m.; of II, .120 m.; of III, .128 m.; of IV, .102 m. Length of foot, .190 m. On one slab from Milford, New Jersey, preserved in the Geological museum, at Lafayette college, a fifth digit, arising near the base of the fourth, is seen, very similar indeed to *Chirotherium*.

Manus: divarication of digits I and II, 29° ; of II and III, 16° ; of III and IV, 40° ; of IV and V, 14° . Length of digit I, .030 m.; of II, .034 m.; of III, .035 m.; of IV, .025 m.; of V, .020 m. Length of entire impression, .075 m.

This form is not *Otozoum*; in fact it suggests *Chirotherium* much more strongly, and further study may prove the identity of this species with the latter.

The type specimen is preserved in the museum of Lafayette college, Easton, Pennsylvania.

Order *INCERTAE SEDIS*.

Forms habitually bipedal.

Genus *Platypterna* E. Hitchcock. (Broad heel.)

Platypterna E. Hitchcock, '45b, p. 25; '58, p. 83.

Generic characters. Bipedal, tridactyl, plantigrade or digitigrade, generally with a broad, rounded heel. Digits narrow, without pad impressions and but rarely showing distinct claws.

This is one of the "leptodaetylous" genera whose characters it is very difficult to make out. It would seem best to place it provisionally with the carnivorous dinosaurs because of the bipedal gait and dinosauroid character of the foot.

Platypterna deaniana E. Hitchcock.

Platypterna deanianus E. Hitchcock, '45b, p. 25; '58, p. 83, pl. 14, fig. 4.

Specific characters. Pes: divarication of digits II and III, 40° to 45°; of III and IV, 25° to 30°; of II and IV, 60° to 70°. Length of digit II, .038 m.; of III, .076 m.; of IV, .051 m. Heel: length, .030 m.; breadth, .023 m. Distance between lateral tips, .051 to .063 m. Length of foot, .100 to .115 m.

E. Hitchcock ('65, p. 2) speaks of this form as of doubtful validity, possibly because of its probable identity with *Sillimanius tetradactylus*.

The type specimen is no. $\frac{32}{26}$, of the Hitchcock cabinet, on fine red shale from Weathersfield, Connecticut.

Platypterna concamerata (E. Hitchcock).

Harpedactylus concameratus E. Hitchcock, '48, p. 207, pl. 14, fig. 3.

Platypterna varica E. Hitchcock, '58, p. 85, pl. 14, fig. 8; pl. 47, fig. 4.

Specific characters. Pes: divarication of digits II and III, 23°; of III and IV, 52°; of II and IV, 75°. Length of digit II, measured from the middle of the heel, .076 m.; of III, .091 m.; of IV, .051 m.; of the heel, .028 m. Width of heel, .050 m. Length of foot, .127 m. Distance between lateral tips, .094 m. Length of step, .200 to .300 m. Width of trackway, .280 m.

This form is peculiar in the size and breadth of the heel and the curvature of the toes. It is also remarkable for the extreme width of the trackway as the specific name implies.

The type specimen is no. $\frac{11}{1}$, of the Hitchcock cabinet, on gray micaceous sandstone from Turner's Falls, Massachusetts.

Platypterna digitigrada E. Hitchcock.

Platypterna digitigrada E. Hitchcock, '58, p. 86, pl. 14, fig. 9; pl. 51, fig. 2.

Specific characters. Pes: divarication of digits II and III, 43°; of III and IV, 37°; of II and IV, 80°. Length of digit II, .020 m.; of III, .030 m.; of IV, .023 m. Distance between lateral tips, .040 m. Length of foot, .050 m.; width of heel, .020 m. Length of step, .100 to .115 m. Width of trackway, .076 m. Toes curving inwards; thick, with acuminate claws.

This track is analogous to that of *Platypterna gracillima*, that is, a further caving of

the mud in the present instance would readily produce the latter, though no real clue to its identity with any other genus is shown.

The type specimen is no. $\frac{86}{16}$, of the Hitchcock cabinet, on shale from Turner's Falls, Massachusetts.

? *Platypterna gracillima* E. Hitchcock.

Platypterna gracillima E. Hitchcock, '58, p. 86, pl. 14, fig. 12.

Specific characters. Pes: divarication of digits II and III, 20° ; of III and IV, 50° ; of II and IV, 70° . Length of digit II, .025 m.; of III, .038 m.; of IV, .032 m. Distance between lateral tips, .036 m. Length of step, .127 to .140 m. Width of trackway, .076 m. Foot digitigrade, outer toes curved inward.

This track is like that of a miniature of *Argoidea redfieldianus*, which is probably to be identified with *Eubrontes divaricatus*. The foot approximates most nearly that of *Grallator gracilis*; but the angles of divarication are far greater in the present form. The species is evidently not of the genus *Platypterna* but is left therein provisionally until further light is had upon its affinities.

The type is no. $\frac{39}{4}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

***Platypterna tenuis* E. Hitchcock.**

Platypterna tenuis E. Hitchcock '45b, p. 25; '58, p. 84, pl. 14, fig. 5; pl. 58, fig. 10.

Specific characters. Pes: divarication of digits II and III, 20° to 30° ; of III and IV, 25° to 30° ; of II and IV, 45° to 60° . Length of digit II, .025 m.; of III, .042 m.; of IV, .035 m. Breadth of heel, .015 m. Distance between lateral tips, .048 m. Length of foot, .069 m. Length of step, .178 m. Width of trackway, .050 m.

The form is semiplantigrade so that the whole foot does not impress; a long limbed, delicate type.

The type specimen is no. $\frac{32}{38}$, of the Hitchcock cabinet, on red shale from Weathersfield, Connecticut.

***Platypterna delicatula* (E. Hitchcock).**

Calopus delicatulus E. Hitchcock, '45b, p. 25.

Platypterna delicatula E. Hitchcock, '58, p. 84, pl. 14, fig. 6; pl. 58, fig. 8.

Specific characters. Pes: divarication of digits II and III, 22° ; of III and IV, 18° ; of II and IV, 40° . Length of digit II, .017 m.; of III, .028 m.; of IV, .019 m.; of the heel, .010 m. Width of heel, .008 m. Distance between lateral tips, .015 m. Length of step, .076 m. Width of trackway, .050 m.

This is the smallest representative of the genus.

Type specimen, no. $\frac{31}{11}$, in the Hitchcock cabinet, on red shale from Weathersfield, Connecticut.

Platypterna recta (E. Hitchcock).

Harpedactylus rectus E. Hitchcock, '48, p. 209, pl. 5, fig. 5; pl. 24, fig. 7.

Platypterna recta E. Hitchcock, '58, p. 84, pl. 14, fig. 7; pl. 47, fig. 3.

Specific characters. Pes: divarication of digits II and III, 10° ; of III and IV, 27° ; of II and IV, 36° . Length of digit II, .055 m.; of III, .080 m.; of IV, .060 m. Distance between the lateral tips, .063 m. Length of track, .095 m. Width of heel, .045 m. Length of step, .140 m. Width of trackway, .140 m.

In this form, as in *P. tenuis*, the foot is semiplantigrade so that the entire foot does not impress. The toes are straight but the short step and wide trackway indicate a very short limbed, wide bodied form as in the case of *P. concamerata*.

The type is no. $\frac{6}{2}$, of the Hitchcock cabinet, on hard argillaceous sandstone, from Gill, Massachusetts.

Genus **Argoides** E. Hitchcock. (Cyclops-like.)

Argoides E. Hitchcock, '45b, p. 24.

Argozoum E. Hitchcock, '58, p. 81.

Generic characters. Bipedal, leptodactylous, tridactylous. Toes curved, the latter ones more or less outward and upward behind, so as to be keel shaped. Digitigrade, rarely showing a heel.

Argoides isodactyletus (E. Hitchcock).

Argoides isodactyletus E. Hitchcock, '45b, p. 24.

Argoides minimus E. Hitchcock, '45b, p. 24.

Argozoum paridigitatum E. Hitchcock, '58, p. 82, pl. 14, fig. 3; pl. 35, fig. 4; pl. 39, fig. 1.

Plesiornis aequalipes E. Hitchcock, '58, p. 104.

Specific characters. Pes: divarication of digits II and III, 40° to 50° ; of III and IV, 40° to 50° ; of II and IV, 80° to 100° . Length of digit II, .023 m.; of III, .033 m.; of IV, .025 m. Distance between the lateral tips, .027 m. Length of foot, .030 m.; of the step, .152 m. Width of trackway, .043 m.

The size coupled with the extreme length of limb in this form, strongly suggests the

genus *Grallator*, but the other characters are so obscure that it is difficult to assure one's self of their identity.

Type, no. $\frac{25}{1}$, of the Hitchcock cabinet, on red shale, with shrinkage cracks, from the Lily pond at Turner's Falls, Massachusetts.

Argoides macrodactylotus (E. Hitchcock).

Platypterna macrodactylotus E. Hitchcock, '45b, p. 25.

Argozoum disparidigitatum E. Hitchcock, '58, p. 82, pl. 14, fig. 2.

Specific characters. Pes: divarication of digits II and III, 18° to 30°; of III and IV, 20° to 25°; of II and IV, 40° to 55°. Length of digit II, .076 m.; of III, .127 m.; of IV, .090 m. Length of foot, .140 m. Distance between lateral tips, .076 m. Length of step, 380 m. Width of trackway, .100 m.

Type, no. $\frac{37}{17}$, of the Hitchcock cabinet, from Weathersfield, Connecticut.

Argoides redfieldianus E. Hitchcock.

Argoides redfieldianus E. Hitchcock, '45b, p. 24.

Argozoum redfieldianum E. Hitchcock, '58, p. 81, pl. 14, fig. 1.

This track agrees in length and divarication of digits with that of *Eubrontes divaricatus* and is undoubtedly synonymous with that species. The analysis of coprolites found associated with these tracks betrays the presence of uric acid which would place the form unquestionably among the Sauropsida but not necessarily with the birds (E. Hitchcock, '58, p. 43).

Argoides robustus E. Hitchcock.

Argoides robustus E. Hitchcock, '45b, p. 24.

This form is not mentioned in any subsequent work, and should therefore be dropped from the list. What disposition was made of the specimens cannot be determined.

Genus ***Tarsoplectrus*** nom. nov. (Spurred tarsus.)

Plectropus E. Hitchcock, '45b, p. 24 (in part).

Plectropterna E. Hitchcock, '58, p. 108 (in part) for *Plectropus*, preoccupied.

Generic characters. Bipedal, tetradactyl, plantigrade, heel narrow, tapering backward, not always wholly impressing. Limbs long; trackway narrow. No phalangeal pads nor distinct claws.

This genus as at present restricted contains but two species, *T. angustus* (E. Hitchcock) and *T. elegans* (C. H. Hitchcock). The name *Plectropterna* unfortunately cannot be retained, as the type species, *P. minitans*, proves to be synonymous with *Anomoepus intermedius*, the old generic name becoming thus a synonym for *Anomoepus*.

The type species is *Tarsoplectrus angustus*.

Tarsoplectrus angustus (E. Hitchcock).

Plectropterna angusta E. Hitchcock, '58, p. 110, pl. 18, fig. 4; pl. 36, fig. 3.

Specific characters. Pes: divarication of digits I and II, 95°; of II and III, 22°; of III and IV, 25°; of II and IV, 47°. Length of digit I, .018 m.; of II, .051 m.; of III, .071 m.; of IV, .046 m. Distance between lateral tips, .040 m. Length of foot, .110 m. Length of step, .305 m. Width of trackway, .068 m. Toes slightly curved. Hallux strongly recurved arising about the middle of the length of the heel.

Type specimen, no. $\frac{33}{39}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Tarsoplectrus elegans (C. H. Hitchcock).

Plectropterna elegans C. H. Hitchcock, '89b, pp. 122, 125.

Specific characters. Pes: divarication of digits II and III, 30°; of III and IV, 40°; of II and IV, 70°. Length of digit I, .023 m.; of II, .026 to .045 m.; of III, .051 to .076 m.; of IV, .038 to .045 m. Length of foot, .127 to .132 m. Distance between lateral tips, .050 to .060 m. Length of step, .457 to .533 m. Width of trackway, .077 m.

Type specimens, nos. 53, 91, and 242, in the Mt. Holyoke cabinet, from Weathersfield, Connecticut.

Genus **Polemarchus** E. Hitchcock. (A leader in war.)

Polemarchus E. Hitchcock, '45b, p. 24; '58, p. 107, pl. 18, fig. 1; pl. 59, fig. 3.

Generic characters. Bipedal, tetradactyl, plantigrade, with broad heel and with a large, half rotated hallux. Toes slender in the track, but the latter, which is of shale, has doubtless caved in to some extent. No pads nor claws in evidence.

Except for the presence of the hallux this form most nearly approximates *Platypterna*. There is but one extremely rare species: *Polemarchus gigas*.

Polemarchus gigas E. Hitchcock.

Polemarchus gigas E. Hitchcock, '45b, p. 24; '58, p. 107, pl. 18, fig. 1; pl. 59, fig. 3.

Specific characters. Pes: divarication of digits I and II, 61°; of II and III, 20°; of

III and IV, 25° ; of II and IV, 45° . Length of digit I, .064 m.; of II, .217 m.; of III, .285 m.; of IV, .213 m.; of the heel, .097 m. Length of foot, .376 m. Width of the heel, .100 m. Distance between tips of the lateral toes, .165 to .222 m. Length of step, 1.224 m. Width of trackway, ? .350 m. The hallux is straight, the other digits curve inward.

The type specimens are nos. $\frac{26}{15}$, $\frac{26}{16}$, and $\frac{26}{17}$, of the Hitchcock cabinet, in slightly calcareous shale, the first two from the middle of the Connecticut river at Chicopee Falls, Massachusetts, the last from near Cabotville, Massachusetts.

Genus **Plesiornis** E. Hitchcock. (Near a bird.)

Plesiornis E. Hitchcock, '58, p. 102.

Generic characters as given by Hitchcock: "tridactylous, pachydactylous, hind foot slightly the largest. Toes slightly turned in towards the line of direction; terminated by blunt claws, or pellets. Highly ornithoid; the tracks distinguished from those of birds only by being arranged two by two along the median line, with a wide interval between." The footprints thus described by Hitchcock under this genus are doubtless in every instance those of two animals walking one after the other, a theory which Hitchcock at first held, but afterwards abandoned on the ground that such tracks occurred too frequently to be thus explained. The so called fore foot track is a typical pes impression and never that of such a manus as one would expect from the very Anomoepus-like appearance of the hind foot. That one animal followed another frequently is not unlikely, if, as the present author believes, the animals resorted to the congregating places for breeding purposes, and the slight difference in size could readily be a sexual character. The quadrupedal nature of the tracks seems amply disproved. Some of the species are referable to known bipedal forms, the others it will be necessary to retain under the present genus, whose revised characters may be thus defined: bipedal, digitigrade, tridactyl forms, digits terminated by blunt or pellet-like claws. Small forms of doubtful affinity.

Plesiornis pilulatus E. Hitchcock.

Plesiornis pilulatus E. Hitchcock, '58, p. 103, pl. 17, fig. 8; pl. 36, fig. 4.

Specific characters. Pes: divarication of digits II and III, 35° ; of III and IV, 35° ; of II and IV, 70° . Length of digit II, .033 m.; of III, .053 m.; of IV, .038 m. Length of foot, .053 m. Distance between lateral tips, .038 m. Length of step, .183 m. Width of trackway, .050 m.

The foot is quite similar to that of *Grallator*, except for the form of the claw and the occasional presence of a spur-like process on the inner side of the foot.

Type, no. $\frac{13}{1}$, of the Hitchcock cabinet, on gray sandstone from Turner's Falls, Massachusetts.

Plesiornis mirabilis E. Hitchcock.

Plesiornis mirabilis E. Hitchcock, '65, p. 35, pl. 20.

Possibly referable to *Anchisauripus tuberosus* E. Hitchcock, especially the larger track, though the smaller track does not resemble it very closely. This species is based upon a single specimen, no. $\frac{51}{16}$, of the Hitchcock cabinet, which is peculiar not only in the lack of similarity of the two sets of footprints, but also in the presence of more or less parallel markings which may be due to dragging tails or limbs or to some other body which may have been drawn along.

Plesiornis giganteus C. H. Hitchcock.

Plesiornis giganteus C. H. Hitchcock, '89b, pp. 118, 122, 126.

Probably referable to *Anchisauripus minusculus*.

Genus **Sillimanius** E. Hitchcock. (For B. Silliman.)

Sillimanius E. Hitchcock, '45b, p. 24.

Ornithopus E. Hitchcock, '48, p. 191.

Generic characters. Bipedal, tetradactylous, hallux rotated so as to be in line with the fourth digit. Digitigrade to semiplantigrade.

This genus is founded on Weathersfield shale specimens and the true characters are obscured. The type species is *Sillimanius tetradactylus* E. Hitchcock.

Sillimanius tetradactylus E. Hitchcock.

Sillimanius tetradactylus E. Hitchcock, '45b, p. 24.

Ornithopus gallinaceus E. Hitchcock, '48, p. 192, pl. 8, fig. 1; '58, p. 87, pl. 14, fig. 10; pl. 58, fig. 1.

Specific characters. Pes: divarication of digits I and II, 110° ; of II and III, 35° ; of III and IV, 45° ; of II and IV, 80° . Length of digit I, .043 m.; of II, .043 m.; of III, .076 m.; of IV, .051 m. Length of foot impression, .097 m. Distance between lateral tips, .069 m. Length of step, .178 m. Width of trackway, .064 m. Foot semiplantigrade.

Type, no. $\frac{32}{41}$, of the Hitchcock cabinet, on red shale, from Weathersfield, Connecticut.

Sillimanus gracilior E. Hitchcock.

Sillimanus gracilior E. Hitchcock, '45b, p. 24.

Ornithopus gracilior E. Hitchcock, '48, p. 193, pl. 8, fig. 2; '58, p. 88, pl. 14, fig. 11; pl. 58, fig. 7.

Specific characters. Pes: divarication of digits I and II, 85° ; of II and III, 35° ; of III and IV, 52° . Length of digit I, .010 m. (impression); of II, .021 m.; of III, .032 m.; of IV, .023 m. Distance between lateral tips, .043 m. Length of foot impression, .043 m. Length of step, .153 m. Width of trackway, .115 m. Foot digitigrade, entire length of the hallux not impressing.

The type specimen is no. $\frac{31}{75}$, of the Hitchcock cabinet, on red shale from Weathersfield, Connecticut.

Genus **Steropoides** E. Hitchcock. (Like Steropus, a Cyclops.)

Steropoides E. Hitchcock, '45b, p. 24.

Steropezoum E. Hitchcock, '48, p. 182.

Tridentipes E. Hitchcock, '58, p. 88 (to replace *Steropezoum*).

Generic characters. Bipedal, tetradactyl, subdigitigrade to semiplantigrade. Tarsus sloping upward so that the impression often ends in ridges and furrows. The hallux is rotated backward so as to be in line with digit IV.

The members of this genus are very similar to those of *Sillimanus* especially to *S. tetradactylus* E. Hitchcock. *Steropoides elegans* may be taken as the type.

Steropoides elegans E. Hitchcock.

Steropoides elegans E. Hitchcock, '45b, p. 24.

Steropoides elegantior E. Hitchcock, '45b, p. 24.

Steropezoum elegans E. Hitchcock, '48, p. 183, pl. 5, fig. 2.

Steropezoum elegantius E. Hitchcock, '48, p. 184, pl. 5, fig. 3.

Tridentipes elegans E. Hitchcock, '58, p. 90, pl. 15, fig. 2; pl. 45, fig. 6; pl. 52, figs. 8, 11.

Specific characters. Pes: divarication of digits I and II, 75° ; of II and III, 65° ; of III and IV, 65° ; of II and IV, 125° . Length of digit I, .046 m.; of II, .046 m.; of III, .071 m.; of IV, .056 m. Distance between lateral tips, .089 m. Length of heel impression, .064 m. Width of heel, .013 m. Length of foot, .135 m. Length of step, .250 to .500 m. Width of trackway, .178 m.

This species is much smaller than the better known *S. ingens*, but very similar to it in form.

Type specimen, no. $\frac{26}{21}$, of the Hitchcock cabinet, is on red shale from Turner's Falls, Massachusetts.

***Steropoides ingens* E. Hitchcock.**

Steropoides ingens E. Hitchcock, '45b, p. 24.

Sillimanianus adamsanus E. Hitchcock, '45b, p. 24.

Steropezoum ingens E. Hitchcock, '48, p. 182, pl. 5, fig. 1.

Ornithopus adamsanus E. Hitchcock, '48, p. 191, pl. 7, fig. 5.

Tridentipes ingens E. Hitchcock, '58, p. 89, pl. 15, fig. 1.

Specific characters. Pes: divarication of digits I and II, 80°; of II and III, 50°; of III and IV, 58°; of II and IV, 107°. Length of digit I, .127 m.; of II, .203 m.; of III, .242 m.; of IV, .145 m. Distance between lateral tips, .282 m. Length of heel impression, .230 m. Length of foot, .460 m.; of the step, 1.020 to 2.020 m.

This is a large but very peculiar track as the metatarsal bones, the so called heel, make a broad and deep impression shoaling out toward the rear as though that segment of the leg were borne at a decided slant. The digits are long and very slender or else the mud has slipped into the track as soon as the foot was withdrawn. There are no digital pad impressions or other characters preserved. The foot is more lacertilian than avian and is totally unlike the typical dinosaurian tracks. Yet from its bipedal gait and the number of digits, the maker of the impression must have been a dinosaur, though unlike any form whose skeletal remains are known.

The type specimen is no. $\frac{16}{12}$, of the Hitchcock cabinet, on gray micaceous sandstone, from Gill, Massachusetts. It is also found on the White hall, New Jersey, slab of red shale, in the Rutgers college museum.

***Steropoides infelix* Hay.**

Steropoides infelix O. P. Hay, :02, p. 552 (to replace *elegantior* a name already used within the genus).

Tridentipes elegantior E. Hitchcock, '58, p. 90, pl. 15, fig. 3; pl. 45, fig. 1 (not *Steropezoum elegantius*, '48).

Specific characters. Pes: divarication of digits I and II, 108°; of II and III, 32°; of III and IV, 44°; of II and IV, 75°. Length of digit I, .010 m.; of II, .015 m.; of III, .029 m.; of IV, .023 m. Distance between lateral tips, .028 m. Length of heel impression, .018 m.; of foot, .045 m. Length of step, .135 m. Width of trackway, .045 m.

Type, no. $\frac{19}{9}$, of the Hitchcock cabinet, on reddish shale from Turner's Falls, Massachusetts.

Steropoides loripes (E. Hitchcock).

Ornithopus loripes E. Hitchcock, '48, p. 193, pl. 8, fig. 3.

Tridentipes insignis E. Hitchcock, '58, p. 91, pl. 15, fig. 4; pl. 45, fig. 3; pl. 47, fig. 2.

Specific characters. Pes: divarication of digits I and II, 55° ; of II and III, 45° ; of III and IV, 50° ; II and III, 95° . Length of digit I, .081 m.; of II, .109 m.; of III, .135 m.; of IV, .109 m. Distance between lateral tips, .160 m. Length of heel impression varies up to .050 m. Length of foot, .152 to .178 m. Length of step, .400 to .567 m. Width of trackway, .317 m.

A long limbed, blunt clawed form; subdigitigrade.

Type specimens, nos. $\frac{1}{4}$ and $\frac{5}{11}$, of the Hitchcock cabinet, on micaceous sandstone, from near Montague, Massachusetts.

Steropoides uncus (E. Hitchcock).

Tridentipes uncus E. Hitchcock, '58, p. 91, pl. 15, fig. 5; pl. 46, fig. 1.

Specific characters. Pes: divarication of digits I and II, 22° ; of II and III, 48° ; of III and IV, 44° ; of II and IV, 90° . Length of digit I, .028 m.; of II, .043 m.; of III, .056 m.; of IV, .036 m. Distance between lateral tips, .056 m. Length of heel, .028 m.; of the foot, .082 m. Length of step, .215 to .227 m. Width of trackway, .155 m.

S. uncus differs markedly from the other members of the genus in the short step and wide trackway, and also in the position of the hallux which is only semirotated.

The type is no. $\frac{6}{1}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Genus **Lagunculapes** E. Hitchcock. (Flask foot.)

Lagunculapes E. Hitchcock, '58, p. 132.

Generic characters. Bipedal, digitigrade, tetradactyl, with the clawless digits widely radiating and more or less flask- or club-shaped, dilating toward their tips; clawless.

There is but one species, *L. latus* E. Hitchcock.

Lagunculapes latus E. Hitchcock.

Lagunculapes latus E. Hitchcock, '58, p. 132, pl. 24, fig. 1; pl. 45, fig. 4.

Specific characters. Pes: divarication of digits I and II, 50° ; of II and III, 70° ; of

III and IV, 65° ; of I and IV, 180° . Length of digit I, .013 m.; of II, .014 m.; of III, .020 m.; of IV, .015 m. Length of foot, .022 m. Width of foot, .032 m. Length of step, .076 m. Width of trackway, .076 m.

Hitchcock considers this form a batrachian because of the similarity to *Proteus* in number of toes and absence of claws. He also likens the form of the toes to that of the toes of the lizard, *Anolis*. The bipedal walk would seem to associate the form with the Reptilia though it hardly agrees with our conception of a dinosaur.

Type, no. $\frac{33}{29}$, of the Hitchcock cabinet, on gray shale from Turner's Falls, Massachusetts.

Forms occasionally quadrupedal.

Genus **Xiphopeza** E. Hitchcock. (Sword foot.)

Xiphopeza E. Hitchcock, '48, p. 239.

Generic characters. Quadrupedal, possibly not habitually so; plantigrade; the tetradactylous pes much larger than the manus which, in the known specimens, impresses but three digits.

Xiphopeza triplex E. Hitchcock.

Xiphopeza triplex E. Hitchcock, '48, p. 239, pl. 15, fig. 8; '58, p. 113, pl. 20, fig. 6; pl. 52, figs. 3, 4, 6.

Specific characters. Pes: divarication of digits I and II, 90° ; of II and III, 40° ; of III and IV, 50° . Length of digit I, .013 m.; of II, .020 m.; of III, .038 m.; of IV, .028 m.; of the heel, .030 m. Length of foot, .066 m. Distance between lateral tips, .038 m. Breadth of heel, .012 m. Length of step, .102 m. Width of trackway, .115 m.

Manus: but three digits impressing, about .010 m. in length.

Type specimen, no. $\frac{41}{26}$, of the Hitchcock cabinet, on gray shale from Turner's Falls, Massachusetts.

Genus **Tarsodactylus** E. Hitchcock. (Toed tarsus.)

Tarsodactylus E. Hitchcock, '58, p. 98.

Generic characters. Quadrupedal, digitigrade; manus pentadactylous, pes tetradactylous with broad digits and somewhat acuminate claws but without phalangeal pads. Tail trace present. A very rare group.

Tarsodactylus caudatus E. Hitchcock.

Tarsodactylus caudatus E. Hitchcock, '58, p. 99, pl. 17, fig. 4; pl. 36, fig. 2.

This form approximates *Anomoepus minimus* closely in size and proportions, being but little larger. It may prove identical.

Type specimen, no. $\frac{42}{5}$, of the Hitchcock cabinet, on shale from Turner's Falls, Massachusetts.

Tarsodactylus expansus C. H. Hitchcock.

Tarsodactylus expansus C. H. Hitchcock, '66, p. 301-302.

Specific characters. Pes: divarication of digits II and III, 25°; of III and IV, 50°; of II and IV, 75° to 80°. Length of digit II, .025 m.; of III, .037 m.; of IV, .028 m. Length of hallux claw, .005 m.; distance from foot, .010 m. Distance between lateral tips, .038 m. Length of foot, .043 m. Length of step, .127 to .178 m. Width of trackway, .140 m.

Manus: divarication of digits I and II, 30°; of II and III, 20°; of III and IV, 25°; of IV and V, 25° to 30°; of I and V, 100°. Length of digit I, .012 m.; of II, .020 m.; of III, .019 m.; of IV, .015 m.; of V, .0095 m. Distance between lateral tips, .025 m. Caudal trace, slight.

This form differs from *T. caudatus* in the greater divarication of the toes; in its smaller size; in its irregular mode of walking as compared with *caudatus*, and the fact that it does not trail the toes as does the latter. This feature may be entirely due to the animal's gait at the time the impressions were made and hence may be of little importance as a distinction.

The type specimen is from near Greenfield, Massachusetts, and is preserved in the cabinet of Prof. C. H. Hitchcock, at Dartmouth college, Hanover, New Hampshire.

Genus **Harpedactylus** E. Hitchcock. (Sickle toed.)

Harpedactylus E. Hitchcock, '45b, p. 24.

Generic characters. Quadrupedal, tetradactylous, plantigrade; heel long, digits sometimes curved inward, sickle-like. This genus represents a group of mud tracks, at least two species of which seem referable to Anomoepodoid forms, while the third, *H. crassus*, is not so typical. The entire group seems to be of doubtful validity.

Harpedactylus tenuissimus E. Hitchcock.

Harpedactylus tenuissimus E. Hitchcock, '45b, p. 24.

Harpedactylus gracilis E. Hitchcock, '58, p. 112, pl. 20, fig. 4; pl. 52, fig. 5.

The known specimens are those of seated animals about the size and proportions of *Anomoepus minimus* E. Hitchcock, and possibly referable to that species.

The type specimen is no. $\frac{27}{18}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts. It seems further possible that *Plectropterna gracilis* E. Hitchcock, may also belong here, as well as *P. lineans* E. Hitchcock.

Harpedactylus gracilior E. Hitchcock.

Harpedactylus gracilior E. Hitchcock, '65, p. 12, pl. 3, fig. 2.

This form is very similar to the preceding species except that it is much smaller and the manus is unknown. It is impossible to refer it to any known *Anomoepus* because of its size, but its affinities are probably with that genus. *H. gracilior* is known from but two specimens, nos. $\frac{47}{52}$ and $\frac{55}{1}$, of the Hitchcock cabinet, both from Turner's Falls, Massachusetts.

Harpedactylus crassus E. Hitchcock.

Harpedactylus crassus E. Hitchcock, '65, p. 12, pl. 3, fig. 1.

This species is based upon a single badly worn specimen showing both manus and pes tracks. It is a characterless track of doubtful affinity. It could, however, have been formed by *Anomoepus scambus* as the size and proportions of fore and hind feet agree; but the subsequent slipping of the mud has distorted the impression very much.

The type specimen is no. $\frac{47}{53}$, of the Hitchcock cabinet, on gray shale; type locality unrecorded.

Subclass SYNAPSIDA Osborn.

Order *TESTUDINATA*.

Quadrupedal forms, generally with short stride and wide trackway indicating short legged, broad bodied creatures. Often with longitudinal traces which may have been made by dragging tail, limbs, or plastron. The reference of the following genera to this order is by no means certain, being based upon President Hitchcock's opinion.

Genus **Ancyropus** E. Hitchcock. (Anchor foot.)

Ancyropus E. Hitchcock, '45b, p. 24; '58, p. 138.

Generic characters. Quadrupedal, plantigrade. Pes tetra- or pentadactylous, hallux semirotated, the other digits turned outward very strongly. Manus tetradactylous, dig-

its as in pes, but much slenderer in proportion to its length. No pad nor claw impressions are preserved.

In several of the specimens it seems as though the foot which made the impression had lain on its side rather than in the normal position, which may account for the peculiar form of the track.

Ancyropus heteroclitus E. Hitchcock.

Ancyropus heteroclitus E. Hitchcock, '45b, p. 24; '58, p. 139, pl. 25, fig. 3-4; pl. 53, fig. 1-2.

Ancyropus jacksonianus E. Hitchcock, '45b, p. 24.

Specific characters. Pes: length of foot, .051 m. Breadth across the toes, .033 m.; across the heel, .020 m. Average length of digits, about .010 m. Length of step, .063 m. Width of trackway, .165 m.

Manus: length, .051 m.; average length of digits, .007 to .008 m. Breadth of palm, .007 m.

The shortness of limbs, width of trackway, and the form of the feet are Chelonia-like, hence this form seems to be included in that order.

Type, no. $\frac{27}{7}$, of the Hitchcock cabinet, on gray shale from Weathersfield, Connecticut.

Genus **Chelonoides** E. Hitchcock. (Tortoise-like.)

Chelonoides E. Hitchcock, '58, p. 140.

Generic characters. Quadrupedal; pes tridactylous, digitigrade, smaller than the plantigrade, pentadactyl manus. No claws nor pads. Limbs long, body wide.

Hitchcock's reference of this form to the Chelonia is based solely upon the width of the body, but the feet are not like those of tortoises nor is there any evidence of a dragging plastron or tail.

Chelonoides incedens E. Hitchcock.

Chelonoides incedens E. Hitchcock, '58, p. 140, pl. 31, fig. 3.

Specific characters. Pes: divarication of digits II and IV, 80°. Length of digit II, .017 m.; of III, .020 m.; of IV, .017 m. Length of foot, .026 m. Length of stride, .180 m. Width of trackway, .165 m.

Manus: divarication of digits II and V, 100°. Length of digit I, .010 m.; of II, .018 m.; of III, .023 m.; of IV, .020 m.; of V, .020 m.; of the heel, .028 m. Length of entire impression, .043 m.

The type specimen is no. $\frac{6}{1}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Genus **Amblypus** E. Hitchcock. (Blunt foot.)

Amblypus E. Hitchcock, '58, p. 143.

Generic characters. Impression of right hind foot only in all of the several specimens which exist. Pes plantigrade, tridactylous with the digits curving inward. No morphological characters. Manus unknown.

All of the specimens are probably the impressions of a single individual which may have been walking along the shore so that the surface under but one foot was in condition to take an impression. Hitchcock thinks the animal a Chelonian as the foot "approximates to that of some tortoises."

Amblypus dextratus E. Hitchcock.

Amblypus dextratus E. Hitchcock, '58, p. 143, pl. 25, fig. 7; pl. 48, fig. 5.

Specific characters. Pes: length of the foot, .025 m.; breadth, about .015 m. Digits not separated. Length of step, .100 to .115 m.

Type specimen, no. $\frac{34}{27}$, of the Hitchcock cabinet, on gray shale, from Turner's Falls, Massachusetts.

Genus **Helcura** E. Hitchcock. (Tail dragger.)

Helcura E. Hitchcock, '48, p. 244.

Generic characters. "Quadrupedal; tail and toes often dragging on the ground." Broad body trace.

These traces give absolutely no data concerning the form and structure of the feet. Hitchcock compares the markings to those left by living land tortoises and hence classes them provisionally with the Chelonia.

The species are: —

Helcura anguinea E. Hitchcock.

Helcura anguinea E. Hitchcock, '58, p. 141, pl. 36, fig. 9.

Specific characters. Length of stride of the same foot, .125 to .150 m. Width of trackway, .075 m.

Type specimen, no. $\frac{40}{8}$, of the Hitchcock cabinet, on gray shale, from Turner's Falls, Massachusetts.

Helcura littoralis E. Hitchcock.

Helcura littoralis E. Hitchcock, '48, p. 244, pl. 15, fig. 1; pl. 23, fig. 3.

Helcura caudata E. Hitchcock, '58, p. 140, pl. 37, fig. 3; pl. 40, fig. 1.

Specific characters. Length of stride, .150 m. Width of trackway, .125 m.

Type specimen, no. $\frac{26}{10}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Helcura surgens E. Hitchcock.

Helcura surgens E. Hitchcock, '58, p. 141, pl. 36, fig. 10.

Specific characters. Width of trackway, .125 to .150 m. No caudal trace.

This species is distinguished from the others by its greater width of body and the absence of a tail trace and of footprints.

Type specimen, no. $\frac{19}{8}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

*INCERTAE SEDIS.**Forms habitually quadrupedal.*Genus **Eupalamopus** Hay.

Eupalamopus O. P. Hay, :02, p. 544 (name given as a substitute for *Palamopus* E. Hitchcock, '48, p. 217, preoccupied by E. Hitchcock in 1845).

Generic characters. ? Quadrupedal. Pes palmated, tetradactylous, all toes directed forward. Heel stout, bent outward. Manus not well known, about one third the length of the pes.

Eupalamopus dananus (E. Hitchcock).

Palamopus dananus E. Hitchcock, '48, p. 217, pl. 9, fig. 1-2.

Palamopus clarki E. Hitchcock, '58, p. 127, pl. 23, fig. 2; pl. 44, fig. 2.

Specific characters. Pes: divarication of digits I and II, 25°; of II and III, 30°; of III and IV, 15°. Length of digit I, .137 m.; of II, .165 m.; of III, .217 m.; of IV, .153 m., measured from the extremity of the heel. Distance between lateral tips, .120 m. Length of foot, .217 m. Length of step, .535 m. Width of trackway, .127 m.

Manus: length, .090 m.; breadth, .038 m. What appears to be the manus impression lies midway between successive tracks of the pes. There are no phalangeal impressions nor distinct claws in the footprints so that the true affinities of this very rare track

cannot be learned. If it is really quadrupedal in its gait it is among the largest of such forms in the Connecticut valley.

The type specimen, which is unique, is no. $\frac{12}{1}$, in the Hitchcock cabinet, from Northampton, Massachusetts, associated with *Eubrontes approximatus* and with *Anchisauripus tuberosus*, *A. tuberatus*, and *A. exsertus*.

Genus **Palamopus** E. Hitchcock. (Palm foot.)

Palamopus E. Hitchcock, '45b, p. 24.

Sillimanius E. Hitchcock, '45b, p. 24 (in part).

Macropterna E. Hitchcock, '58, p. 128.

Dr. O. P. Hay (:02, p. 548) says: "This is not the *Palamopus* of 1848 and subsequently. The latter is here represented by *Eupalamopus*."

Generic characters. Quadrupedal; manus and pes of unequal size, the latter being from two to three times the length of the former. Feet plantigrade. Pes tetradactyl. Manus pentadactyl; no claw nor phalangeal pad impressions. Caudal trace sometimes present.

Palamopus anomalus E. Hitchcock.

Palamopus anomalus E. Hitchcock, '45b, p. 24.

Macropterna recta E. Hitchcock, '48, p. 235, pl. 15, fig. 6.

Specific characters. Pes: divarication of digits I and II, 10° ; of II and III, 30° to 35° ; of III and IV, 35° ; of I and IV, 75° to 80° . Length of digit I, .023 m.; of II, .032 m.; of III, .041 m.; of IV, .028 m.; of the heel, .036 m.; of the foot, .077 m. Distance between lateral tips, .040 to .046 m. Breadth of heel, .010 to .015 m. Length of step, .195 m. Digits nearly straight.

Manus: divarication of digits I and II, 30° ; of II and III, 35° ; of III and IV, 35° ; of I and IV, 100° . Length of digit I, .006 m.; of II, .010 m.; of III, .023 m.; of IV, .018 m. Digit V not impressing. Distance between lateral tips, .030 m.

This form is not mentioned by either Hitchcock after 1848. The only specimen which it is possible to identify among those mentioned in 1848, is the old no. 33, now $\frac{40}{64}$, of the Hitchcock cabinet and correctly referred in the catalogue to *Palamopus divaricans*.

Palamopus divaricans (E. Hitchcock).

Macropterna divaricans E. Hitchcock, '48, p. 237, pl. 15, fig. 7; '58, p. 129, pl. 23, fig. 7.

Specific characters. Pes: divarication of digits I and II, 20° ; of II and III, 30° ; of III and IV, 40° ; of I and IV, 90° . Length of digit I, .013 m.; of II, .015 m.; of III, .027 m.; of IV, .015 m. Distance between lateral tips, .030 m. Length of heel, .043 m.; of foot, .069 m. Breadth of heel, .012 m. Length of step, .084 to .178 m. Width of trackway, .076 m.

Manus: with five digits radiating through about 180° . Length, .023 m.; breadth, .018 m.

Type specimen, no. $\frac{27}{3}$, of the Hitchcock cabinet, on red shale from Turner's Falls, Massachusetts.

***Palamopus gracilipes* (E. Hitchcock).**

Macropterna gracilipes E. Hitchcock, '58, p. 129, pl. 13, fig. 6; pl. 34, fig. 1.

Specific characters. Pes: divarication of digits I and II, 40° ; of II and III, 25° ; of III and IV, 25° ; of I and IV, 90° . Length of digit I, .004 m.; of II, .007 m.; of III, .008 m.; of IV, .007 m.; of heel, .007 m.; of foot, .015 m. Length of step, .060 to .070 m. Width of trackway, .030 m.

Manus: but four digits impressing; form and divarications about that of the pes. Length, .005 m.; breadth, .009 m.

Type specimen, no. $\frac{35}{23}$, of the Hitchcock cabinet, on shale from Turner's Falls, Massachusetts.

***Palamopus rogersianus* (E. Hitchcock).**

Sillimanius rogersianus E. Hitchcock, '45b, p. 24.

Macropterna rhynchosauroidea E. Hitchcock, '48, p. 233, pl. 15, fig. 9.

Macropterna vulgaris E. Hitchcock, '58, p. 128, pl. 23, fig. 5; pl. 35, fig. 9; pl. 37, fig. 4; pl. 48, fig. 7; pl. 49, fig. 3; pl. 59, fig. 5.

Specific characters. Pes: divarication of digits I and II, 30° ; of II and III, 20° ; of III and IV, 30° ; of I and IV, 80° . Length of digit I, .005 m.; of II, .009 m.; of III, .013 m.; of IV, .013 m.; of the heel, .015 m.; of the foot, .028 m. Length of step, .046 m. Width of trackway, .050 m.

Manus: five digits impressing, ranging through 180° . Length, .015 m.; breadth, .011 m.

Caudal trace sinuous, not always present.

Type specimens, nos. $\frac{36}{25}$ and $\frac{39}{79}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Genus **Exocampe** E. Hitchcock.

Exocampe E. Hitchcock, '58, p. 142.

Generic characters. Quadrupedal. Pes tetradactylous, digitigrade, heel occasionally impressing; the three outermost digits curved outward from the line of direction.

Manus pentadactylous, about one half the length of the pes; not always impressing. Legs moderately long, as indicated by the long step and the narrow trackway. No morphological characters exhibited by the tracks.

The type species is *Exocampe arcta*.

Exocampe arcta E. Hitchcock.

Exocampe arcta E. Hitchcock, '58, p. 142, pl. 25, figs. 5, 6, 10; pl. 49, fig. 5.

Specific characters. Pes: divarication of outer toes, 110° . Length of digit I, .020 m.; of II, .028 m.; of III, .033 m.; of IV, .033 m. Length of heel, .020 m.; of the foot, .048 m. Length of step, .217 m. Width of trackway, .075 m.

Manus: divarication of lateral digits, 110° . Length of digit I, .009 m.; of II, .023 m.; of III, .025 m.; of IV, .025 m.; of V, .013 m. Digits much less curved than are those of the pes. Manus position in advance of the pes and much farther from the median line.

The type is no. $\frac{35}{24}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Exocampe ornata E. Hitchcock.

Exocampe ornata E. Hitchcock, '58, p. 143, pl. 25, fig. 11; pl. 48, figs. 1, 6.

Specific characters. Pes: divarication of lateral digits, 100° to 130° . Length of digit I, .006 m.; of II, .007 m.; of III, .010 m.; of IV, .008 m. Length of step, .055 m. Width of trackway, .025 m.

Manus: Four digits directed forward, and one to the rear; divarication of the former, 130° . Length of manus, .013 m.

Exocampe ornata differs from *E. arcta* in its smaller size and more delicate form.

Type specimens, nos. $\frac{39}{69}$ and $\frac{41}{39}$, in the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Exocampe minima E. Hitchcock.

Exocampe minima E. Hitchcock, '65, p. 11, pl. 18, fig. 3.

Exocampe minima C. H. Hitchcock, in E. Hitchcock, '65, appendix C, p. 89.

Specific characters. Pes: divarication of lateral digits, 100° to 130° . Length of digit I, .003 m.; of II, .0065 m.; of III, .008 m.; of IV, .0045 m. Very delicate claws sometimes impress. Length of step, .028 to .050 m. Width of trackway, .038 m.

Manus: one short hind toe and four front ones, the latter with a divarication of 138° . Digits vary in length from .004 to .005 m. Nearly straight.

Type specimen, no. $\frac{55}{4}$, of the Hitchcock cabinet, from Gill, Massachusetts.

Genus **Orthodactylus** E. Hitchcock. (Straight toed.)

Orthodactylus E. Hitchcock, '58, p. 113.

Generic characters. Quadrupedal, digitigrade. Pes with four long, straight digits, diverging but little; clawless and without phalangeal pads. Manus pentadactyl, digits ranging through 180° or more of divarication. Impression just in advance of that of the pes.

Hitchcock classes these forms with the lizards but their true position seems extremely doubtful as the data which they furnish is so meager.

Orthodactylus floriferus E. Hitchcock.

Orthodactylus floriferus E. Hitchcock, '58, p. 114, pl. 20, fig. 7; pl. 45, fig. 2.

Specific characters. Pes: divarication of digits I and II, 12.5° ; of II and III, 4° ; of III and IV, 9.5° ; of I and IV, 25° . Length of digit I, .015 m.; of II, .020 m.; of III, .030 m.; of IV, .018 m. Distance between lateral tips, .013 m. Axis of foot turned outward 35° to 40° . Length of step, about .180 m. Width of trackway, .182 m.

Manus: with subequal digits about .013 m. in length, ranging through 180° .

Type specimen, no. $\frac{6}{1}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Orthodactylus introvergens E. Hitchcock.

Orthodactylus introvergens E. Hitchcock, '58, p. 114, pl. 20, fig. 8; pl. 51, fig. 1.

Specific characters. Pes: divarication of lateral toes, rarely more than 20° . Digits straight, very narrow, from .020 to .032 m. in length. Length of foot, .039 m. Distance between lateral tips, .025 m. Length of step, .054 m. Width of trackway, .083 m.

Manus: digits somewhat curved, about half the length of the pes. The axis of both manus and pes turn in toward the median line, a fact which constitutes the main point of difference between this and the preceding species, in which the reverse is true.

The type specimen is no. $\frac{32}{50}$, of the Hitchcock cabinet, on red shale from Turner's Falls, Massachusetts.

Orthodactylus linearis E. Hitchcock.

Orthodactylus linearis E. Hitchcock, '58, p. 115, pl. 20, fig. 9; pl. 48, fig. 4.

Specific characters. Pes: digits nearly parallel, the divergence of the lateral ones being not over 20° . Digits ranging in length from .007 to .013 m. Length of step, .043 m. Width of trackway, .038 m.

Manus: apparently similar to the pes though much slenderer.

This species is much smaller and more slender than the others of its genus. The fact of its dragging tail and feet in the type specimen is probably only accidental and not a specific habit.

The type is no. $\frac{27}{15}$, of the Hitchcock cabinet, on red shale from Turner's Falls, Massachusetts.

Genus **Antipus** E. Hitchcock. (Opposite foot.)

Antipus E. Hitchcock, '58, p. 115.

Generic characters. Quadrupedal, digitigrade. Pes tetradactylous, manus pentadactylous, without claw or phalangeal impressions.

This genus is named from the peculiar position of the tracks on the slab, those of the manus and pes pointing in nearly opposite directions. This is probably due to the fact that the lasting impression was made in a particular stage in the creature's walk which was evidently similar to the sprawling gait of the lizards and turtles. The tracks, aside from their position, resemble most closely those of the genus *Sustenodactylus*.

Antipus flexiloquus E. Hitchcock.

Antipus flexiloquus E. Hitchcock, '58, p. 115, pl. 20, fig. 10.

Specific characters. Pes: divarication of lateral digits, 60° . Length of digit I (the outermost as the impression lies), .018 m.; of II, .020 m.; of III, .020 m.; of IV, .019 m. Length of foot, .029 m. Distance between lateral tips, .025 m. Length of step, .038 to .084 m. Width of trackway, .127 m.

Manus: divarication of lateral digits, 131° . Length of hand, .023 m.; breadth, .021 m.

The type is no. $\frac{41}{52}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Antipus bifidus E. Hitchcock.

Antipus bifidus E. Hitchcock, '58, p. 116, pl. 36, fig. 8; pl. 48, fig. 10.

This is an extremely doubtful species.

Genus **Sustenodactylus** nom. nov. (Running to a narrow point.)

Stenodactylus E. Hitchcock, '58, p. 116 (name preoccupied):

Generic characters. Quadrupedal, digitigrade; pentadactyl manus and pes. Digits extremely slender and tapering, without claws or pads. Pes about twice the size of the manus.

Sustenodactylus curvatus (E. Hitchcock).

Stenodactylus curvatus E. Hitchcock, '58, p. 116, pl. 20, fig. 11; pl. 34, fig. 3.

Specific characters. Pes: divarication of the lateral digits, 70° . Length of digit I, .018 m.; of II, .020 m.; of III, .026 m.; of IV, .022 m.; of V, .0065 m., vestigial. Length of foot, .026 m. Length of step, .090 m. Width of trackway, .064 m.

Manus: divarication of lateral digits, 180° . Length of digit I, .006 m.; of II, .007 m.; of III, .013 m.; of IV, .014 m.; of V, .003 m.

Type specimen, no. $\frac{34}{43}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Genus **Isocampe** E. Hitchcock. (Equal curve.)

Isocampe E. Hitchcock, '58, p. 119.

Generic characters. Quadrupedal; manus and pes of unequal size, the former tetradactylous, possibly pentadactylous; the latter tetradactylous. Digits of the pes nearly parallel and curved toward the median line; those of the manus nearly straight, divergent. No pads nor claws. Digitigrade; with a caudal trace. A short limbed, broad bodied form.

Isocampe strata E. Hitchcock.

Isocampe strata E. Hitchcock, '58, p. 120, pl. 20, fig. 5; pl. 36, fig. 5.

Specific characters. Pes: digits parallel. Length of digit I, .042 m.; of II, .051 m.; of III, .058 m.; of IV, .055 m. Length of step, .161 m. Width of trackway, .078 m.

Manus: divarication of digits I and II, 5° ; of II and III, 5° ; of III and IV, 25° ; of I and IV, 35° . Length of digit I, .028 m.; of II, .043 m.; of III, .030 m.; of IV, .028 m. Position of manus a little in advance of, and within the pes impression.

Type specimens, no. $\frac{40}{62}$, from Turner's Falls, Massachusetts, and no. $\frac{26}{4}$, from Middletown, Connecticut, both in the Hitchcock cabinet.

Genus **Shepardia** E. Hitchcock.

Shepardia E. Hitchcock, '58, p. 131.

Generic characters. Quadrupedal; feet nearly equal in size. Manus pentadactylous. Pes with a vestigial fifth digit; apparently webbed.

Shepardia palmipes E. Hitchcock.

Shepardia palmipes E. Hitchcock, '58, p. 131, pl. 24, fig. 2.

Specific characters. Pes: divarication of digits I and II, 10° ; of II and III, 13° ; of III and IV, 14° ; of I and IV, 37° . Length of digit I, .013 m.; of II, .025 m.; of III, .030 m.; of IV, .023 m. Distance between lateral tips, .022 m. Length of foot, .030 m.

Manus: divarication of digits I and II, 30° ; of II and III, 25° ; of III and IV, 20° ; of IV and V, 30° . Length of digit I, .010 m.; of II, .018 m.; of III, .023 m.; of IV, .026 m.; of V, .010 m. Distance between lateral tips, .018 m.

Type specimen in the Shepard collection at Amherst college, from Turner's Falls, Massachusetts.

Genus **Comptichnus** E. Hitchcock. (Elegant track.)

Comptichnus E. Hitchcock, '65, p. 9.

Generic characters. Quadrupedal, tetradactylous, digitigrade. Digits of the pes broad, showing neither claw nor phalangeal impressions, those of the manus making peculiar oval marks.

Comptichnus obesus E. Hitchcock.

Comptichnus obesus E. Hitchcock, '65, p. 9, pl. 5, fig. 4; pl. 18, fig. 6.

Specific characters. Pes: divarication of digits I and II, 28° ; of II and III, 20° ; of III and IV, 14° . Length of digit I, .0065 m.; of II, .009 m.; of III, .013 m.; of IV, .010 m. Length of foot, .015 m. Length of step, .065 m. Width of trackway, .038 m.

Manus: four oval impressions, three slightly radiating in front, one behind. Length of the track, .008 m.

Type specimen, no. $\frac{5.5}{5}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Genus **Arachnichnus** E. Hitchcock. (Spider track.)

Arachnichnus E. Hitchcock, '58, p. 117.

Generic characters. Quadrupedal, plantigrade. Pes tetradactylous, as is also the impression of the manus. Limbs moderately long; body wide.

Arachnichnus dehiscens E. Hitchcock.

Arachnichnus dehiscens E. Hitchcock, '58, p. 117, pl. 20, fig. 12-13; pl. 38, fig. 2.

Specific characters. Pes: divarication of lateral anterior digits, 150°. Length of foot, .028 m.; breadth, .017 m. Length of step, .076 to .114 m. Width of trackway, .076 m.

Manus: divarication of lateral digits, 180°. Length of impression, .009 m. Breadth, .013 m.

The footprints are obscured by radiating sun cracks but their nearest affinity seems to be with *Palamopus*.

Type specimen, no. $\frac{51}{18}$, of the Hitchcock cabinet, on shale from Turner's Falls, Massachusetts (figured in E. Hitchcock, '65, pl. 17, fig. 2).

Genus **Triaenopus** E. Hitchcock. (Anchor foot.)

Triaenopus E. Hitchcock, '45b, p. 24.

Generic characters. Author's description: "Quadrupedal, tetradactylous on both fore and hind feet. Toes slender and long; three directed forward with small divarication. Fourth toe coming out near the extremity of a long heel."

This is a Weathersfield shale genus and, while very common, is extremely obscure as to its true characters. It is nearly impossible to distinguish the fore and hind feet and we may have another instance¹ in which the successive tracks of two bipedal animals appear as those of one quadruped.

Triaenopus baileyanus E. Hitchcock.

Triaenopus baileyanus E. Hitchcock, '45b, p. 24.

Triaenopus emmonsianus E. Hitchcock, '45b, p. 24.

Triaenopus leptodactylus E. Hitchcock, '58, p. 111, pl. 19, fig. 1-9; pl. 20, fig. 1-3; pl. 45, fig. 8; pl. 52, fig. 1.

Hitchcock here substituted the name *T. leptodactylus* for the species whose pes was formerly described as *T. baileyanus*, the manus as *T. emmonsianus*. The name *T. baileyanus* takes precedence.

Type specimen, no. $\frac{31}{27}$, of the Hitchcock cabinet, on red shale, from Weathersfield, Connecticut.

¹ *Vide* Plesiornis, p. 521.

Genus **Cunichnoides** E. Hitchcock. (Dog-like track.)

Cunichnoides E. Hitchcock, '58, p. 54.

Generic characters. Quadrupedal; fore feet rather the smaller. Ball of the foot making a distinct impression with at least four circular impressions arranged nearly on a semicircle in front of that made by the ball. No claw impressions.

This footprint bears a rather faint resemblance to that of a dog or cat, especially the latter because of the absence of claws, but the impression which would represent the ball of the foot is not differentiated from the impressions of the digits as in the modern Carnivora. The impressions are certainly not reptilian and may possibly be mammalian, but it seems likely, in view of their rarity, that the creature which made the tracks was abnormal.

Cunichnoides marsupialoideus E. Hitchcock.

Cunichnoides marsupialoideus E. Hitchcock, '58, p. 55, pl. 9, fig. 5; pl. 40, fig. 2.

Type specimen, no. $\frac{29}{2}$, of the Hitchcock cabinet, from Portland, Connecticut.

GENERA OF DOUBTFUL VALIDITY.

Genus **Anticheiropus** E. Hitchcock. (Thumb foot.)

Anticheiropus E. Hitchcock, '65, p. 10.

Generic characters. Bipedal, digitigrade, tetradactyl. Digits broad but without phalangeal pads. The name is based upon the fact that one toe is offset like a thumb. In *A. pilulatus* it is evidently digit II which is thus offset, whereas in *A. hamatus* it is digit IV. The latter bears a strong resemblance to *Anomoepus crassus* except that in the latter the divarication between digits III and IV is not so great.

Each species is based upon but a single specimen which in both instances may be abnormal.

Anticheiropus pilulatus E. Hitchcock.

Anticheiropus pilulatus E. Hitchcock, '65, p. 10, pl. 9, fig. 3.

Specific characters. Pes: divarication of digits II and III, 75° ; of III and IV, 15° ; of II and IV, 90° . Length, measured to rear of impression, of digit II, .255 m.; of III, .457 m.; of IV, .315 m.; of the foot, .520 m. Distance between lateral tips, .420 m. Claws broad and rounded, pellet-like. There is an oval depression beside digit II

which Hitchcock attributed to the hallux but its position is such that this seems highly improbable.

This is among the largest of the footprints and is so peculiar that one can see no similarity to any other form. More material is needed before its true nature is determined.

Type specimens, nos. $\frac{10}{4}$ and $\frac{10}{5}$, counterparts, in the Hitchcock cabinet, from Montague, Massachusetts.

Anticheiropus hamatus E. Hitchcock.

Anticheiropus hamatus E. Hitchcock, '65, p. 10, pl. 9, fig. 1-2.

Specific characters. Pes: divarication of digits II and III, 20° to 40° ; of III and IV, 90° ; of II and IV, 100° . Length of digit II, .085 m.; of III, .110 m.; of IV, .050 to .060 m.; of the foot, .180 m. Distance between lateral tips, .200 m. Length of step, .400 m. There are no distinct claws though the ends of the digits are pointed.

This is certainly a questionable species.

Type specimen, no. $\frac{51}{17}$, of the Hitchcock cabinet, on red shale from Turner's Falls, Massachusetts.

Genus **Hoplichnus** E. Hitchcock. (Hoof track.)

Hoplichnus E. Hitchcock, '48, p. 230.

Generic characters. Quadrupedal; hind foot somewhat the largest; track hoof-shaped. These tracks have no sign of digit or claw and are doubtfully referable to vertebrates at all.

Hoplichnus equus E. Hitchcock.

Hoplichnus equus E. Hitchcock, '58, p. 134, pl. 24, figs. 3, 5.

Hoplichnus quadrupedans E. Hitchcock.

Hoplichnus quadrupedans E. Hitchcock, '48, p. 230, pl. 16, fig. 7-8; pl. 22, fig. 3.

Hoplichnus poledrus E. Hitchcock, '58, p. 136, pl. 24, fig. 6-7; pl. 48, fig. 9.

Both forms are from Massachusetts and the types are in the Hitchcock ichnological cabinet, nos. $\frac{29}{3}$ and $\frac{36}{1}$, respectively.

Genus **Toxichnus** E. Hitchcock. (Bow track.)

Toxichnus E. Hitchcock, '65, p. 12.

Generic characters. Quadrupedal, digitigrade, tetradactylous, leptodactylous.

This genus with its single species, *T. inaequalis*, is known from but two specimens which are somewhat dissimilar and whose true characters cannot be learned. Hence it is very doubtful whether this should be considered a valid genus.

Toxichnus inaequalis E. Hitchcock.

Toxichnus inaequalis E. Hitchcock, '65, p. 12, pl. 5, fig. 5.

Genus **Trihamus** E. Hitchcock. (Three hooks.)

Trihamus E. Hitchcock, '65, p. 9.

Generic characters. Bipedal, tridactyl, digitigrade; heel large, toes slender, inwardly curving like hooks.

This genus was founded upon a single specimen of two successive tracks.

Trihamus elegans E. Hitchcock.

Trihamus elegans E. Hitchcock, '65, p. 9, pl. 2, fig. 3.

Specific characters. Pes: divarication of digits II and IV, 70° to 80°. Length of digit II, .015 m.; of III, .019 m.; of IV, .023 m. Length of heel, .008 m.; of the foot, .030 m. Distance between lateral tips, .020 to .023 m. Length of step, .140 m.

This form is long of limb and seems to have had proportions which suggest a small *Grallator*, but the foot characters so far as can be learned are quite different.

The type is no. $\frac{47}{30}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Trihamus magnus C. H. Hitchcock.

Trihamus magnus C. H. Hitchcock, '89b, pp. 118, 126.

Hitchcock describes this form as being very like *T. elegans*, save in size. Length of step, .150 m.

Type, in Mt. Holyoke museum.

Genus **Typopus** E. Hitchcock. (Type, Syriac, foot.)

Typopus E. Hitchcock, '45b, p. 25.

This genus seems to be founded upon abnormal feet, distorted beyond recognition, and while two specimens exist of each species the tracks were found in each case well within one animal's range.

Typopus abnormis E. Hitchcock.

Typopus abnormis E. Hitchcock, '45b, p. 25; '58, p. 105, pl. 17, fig. 9; pl. 45, fig. 7.

This form is much larger than the following species.

Type specimens, nos. $\frac{19}{1}$ and $\frac{19}{2}$, of the Hitchcock cabinet, from Turner's Falls, Massachusetts.

Typopus gracilis E. Hitchcock.

Typopus gracilis E. Hitchcock, '58, p. 106, pl. 17, fig. 10.

Founded upon a single track and its counterpart on the red shale of Weathersfield, Connecticut; nos. $\frac{31}{36}$ and $\frac{31}{46}$ of the Hitchcock cabinet.

CONCLUSIONS.

The creatures, the record of whose existence has remained impressed upon the ancient shales and sandstones, may be divided into two groups in accordance with their mode of progression: those of bipedal and those of quadrupedal gait. The former, it may be safely assumed, are, in all probability, dinosaurs, for aside from man, many birds, and some modern lizards, they are the only vertebrates whose gait when erect could have been a true walk or run with alternating steps, which without exception, the bipedal tracks show, there being no instance of the record of a jumping form. The presence of birds in the new red sandstone has not been proven, lizards are never *habitual* bipeds, man is clearly out of the question, hence by elimination we narrow the possible origin of such tracks down to the dinosaurian forms. This conclusion is strengthened by the presence of the fossil bones of the *Anchisauridae*, a family of primitive carnivorous dinosaurs having affinities with the Megalosauria.

The most abundant of the tracks are attributable to members of that family, creatures ranging in size from about seven to fourteen feet, so truly bipedal that the manus and tail never impress. The pes is tetradactyl but only exceptionally does the claw of the strong grasping hallux leave a mark. The claws are rather pointed and the whole foot is very bird-like. These footprints form a natural group to which the generic name of *Anchisauripus* is given and which corresponds to the family *Anchisauridae*.

Allied to *Anchisauripus* is another carnivorous form whose foot is more specialized than that of the former in the enfeeblement of the hallux and increase of weight which has rendered the foot flatter and its pads more complex. This creature, *Gigandipus*, reminds one strongly of the Jurassic *Allosaurus* though in the latter the claws were probably more trenchant and the whole foot more efficient as a grasping organ. *Gigandipus*, known from but one specimen, shows a sinuous caudal trace. The dragging of the

tail probably was not habitual, but occurred only when the animal was slowing down before stopping.

Another abundant genus is *Grallator* characterized by very long limbs and small, compact feet without an impressing hallux and with no tail trace. The proportions of length of limbs to those of feet are the same as in the bustards and the forms which made the tracks were probably aberrant carnivores of habits somewhat similar to those of wading birds, possibly feeding upon feebler reptiles and amphibians, or on fish. In considering the probable relationship of this genus to genera known from their skeletal remains one is reminded strongly of *Ornithomimus*, a Cretaceous Compsognathoid dinosaur. *Grallator* comprises for the most part, small forms, the smallest species, *G. gracilis*, indicating a creature but two thirds the size of *Compsognathus*, the smallest known dinosaur, whose dimensions may be compared with those of the domestic cat.

Among the habitually bipedal forms, those which never impress the manus, is one group to which the name *Eubrontes* has been given. It includes larger and heavier forms than *Anchisauripus* with more blunted claws, but Hitchcock included it with the latter under the name *Eubrontes* and the later name *Brontozoum*. The two genera are so different in character that the present author is constrained not only to separate them generically but ordinally as well, for the lack of a grasping hallux, the heavy, slow moving tread, and the blunter claws are surely not carnivorous characteristics, but seem to point rather to an herbivorous habit of life. It may be that instead of being Orthopod or Predentate dinosaurs the *Eubrontes* represent another group of aberrant Carnivora, which like the condor (*Sarcorhamphus gryphus*) because of carrion feeding habits, did not retain the raptorial claws of its predacious allies. The genus *Eubrontes* while few as to species contains some of the most impressive forms which are fairly numerous as to individuals. *Eubrontes giganteus* represents an animal of massive proportions and of about twenty feet in length, which is nearly the maximum for American Triassic dinosaurs, though much inferior in size to those of the Jurassic and Cretaceous periods. Dinosaurs beyond question herbivorous in their habits and hence belonging to the order Orthopoda, are the occasionally quadrupedal forms which, though walking on the hind feet, placed the fore feet on the ground while sitting. This shows that on both manus and pes the claws are short and rounded and no longer subserve a grasping function. The particular interest which attaches to this fact is that it is the first evidence we have of Orthopoda or Predentate dinosaurs in the Trias, for their skeletal remains are entirely unknown either in this country or in Europe from the rocks of that period.

Anomoepus, the most characteristic genus among the herbivorous forms, had a pentadactyl manus with rounded claws and a tetradactyl pes with somewhat longer, but still blunted claws. The hallux was but half rotated and therefore ill fitted for grasping and

there was a long metatarsus, or heel, on which the creature rested. The tail sometimes dragged just before the owner came to rest but at other times was held clear of the ground as a counterpoise to the anterior part of the body as in other genera. *Anomoepus* represents a group of small, lightly built creatures ranging in size from *A. minimus*, about three feet in length, to *A. crassus*, a New Jersey form, six feet long. They are among the most numerous and interesting of all of the ichnite genera with the exception of *Anchisauripus*.

The genus *Fulicopus*, which the writer has separated from the preceding group, shows a greater amount of weight borne on the hind limbs while sitting, the manus resting but lightly as with the kangaroo. The feet resemble those of *Anchisauripus* more than those of *Anomoepus*, there being less divarication or diverging of the digits, though the position of the hallux is as in the latter genus. A curious heart shaped impression frequently occurs just behind and between the impressions of the heels and this was attributed by Hitchcock to the end of a truncated tail, but the writer believes it to have been made by a callosity beneath the apposed extremities of the ischial bones. *Hypsilophodon*, of the Wealden of Europe, most nearly suggests the probable skeletal characters of the *Anomoepodoid* forms and as Professor Osborn has shown, presents the most primitive characters of any known Orthopod. It is difficult to conjecture the probable habits of *Anomoepus*, other than that the animals were herbivorous. They probably came to the mud flats mainly for breeding purposes as their tracks very frequently exhibit a distinct sexual dimorphism between the footprints of the two individuals.

A very striking though rare form, *Otozoum*, has been placed by the present writer among the Orthopoda although the structure of its foot is unlike that of any known dinosaur. *Otozoum* is probably bipedal though there is a possibility that the great pes may have obliterated the track of the much smaller manus. The foot is plantigrade, tetradactyl, with all of the digits pointing forward and with rounded pellet-like claws and a broadly expanding web or fleshy pad extending some distance beyond the ends of the digits. Its probable function was that of supporting the creature on soft mud rather than a natatorial one. The phalangeal formula of the pes is typically dinosaurian, while that of the manus, 2. 3. 3. 3. 3, is amphibian or cotylosaurian and would be absolutely unique in a dinosaur. The manus is rarely seen and is so obscure that there is a reasonable doubt as to the correctness of its interpretation. In one instance a dragging tail is shown which is absent in all other specimens and which is evidence in favor of the belief that the animal is a biped. *Otozoum* has the largest track of all, measuring twenty inches in length, but the author has no conception of the appearance of the creature itself.

Among the so called leptodactylous or narrow toed tracks, are many made by bipedal forms which were doubtless dinosaurs, some carnivorous, and some, judging from the

manus which is occasionally seen, herbivorous in habits. The subsequent slipping of the mud after the withdrawal of the foot has obliterated most of the morphological characters from the impressions. Some of the leptodactylous forms have been identified with the better known genera and species, others which cannot be so identified because of their obscurity may nevertheless be identical with known forms, while still others evidently do not occur elsewhere. It is a notable fact that while the number of genera and species which have been erected upon these impressions is large, the number of individuals represented is proportionately small and these are mainly from one or two localities.

Of the truly quadrupedal forms the most interesting is *Batrachopus*, whose long limbs, tetradactyl, plantigrade pes with acuminate claws, and phalangeal formula of 2. 3. 4. 5, and whose pentadactyl manus are such as one would expect to find in the dinosaurian ancestor. It seems possible therefore, that *Batrachopus* represents a persistent type whose affinities are near the dinosaur stem form and which should be classed with *Kadalisaurus* in the superorder *Diaptosauria* of Osborn. *Batrachopus* may have been a true dinosaur which had retained, among other primitive characters, the ancestral quadrupedal gait. The mode of progression was a true walk like that of a mammal and not the sprawling crawl of modern reptiles. *Batrachopus* included small forms of carnivorous habits.

There remain other quadrupedal forms, generally of small size, whose tracks, aside from the number of digits, size of the foot, and the length of limb, afford almost no data whereon to base a theory as to their affinities. Professor Osborn has likened ichnological interpretation to the deciphering of ancient cuneiform inscriptions which are utterly unintelligible unless one possesses the key. That the key to the deciphering of the dinosauroid tracks has been found seems evident, but in the attempt at the interpretation of the obscurer quadrupedal footprints the student is still very much in the dark.

BIBLIOGRAPHY.¹

Adams, C. B.

- '46. Notice of a small ornithichnite. Amer. journ. of sci. and arts, ser. 2, vol. 2, p. 215-216, text fig. 1-2.

Baur, G.

- '87. On the phylogenetic arrangement of the Sauropsida. Journ. of morphology, vol. 1, p. 93-104.

Beasley, H. C.

- '96. An attempt to classify the footprints in the new red sandstone of this [Liverpool] district. Proc. Liverpool geol. soc., 37th session, vol. 7, pt. 4, p. 391-409, pl. 1-3.

Beckles, S. H.

- '51. On supposed casts of footprints in the Wealden. Quart. journ. geol. soc. London, vol. 7, p. 117.
'54. On the ornithoidichnites of the Wealden. Quart. journ. geol. soc. London, vol. 10, p. 456-464, 1 text fig.
'59. On fossil footprints in the sandstone at Cummingstone. Quart. journ. geol. soc. London, vol. 15, p. 461.
'62. On some natural casts of reptilian footprints in the Wealden beds of the Isle of Wight and of Swanage. Quart. journ. geol. soc. London, vol. 18, p. 443-447, text fig. 1-4.

Bernhardi, Reinhard.

- '34. [On tracks found near Hildburghausen.] Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1834, p. 641-642.

Bouvé, T. T.

- '59. [On priority of discovering footprints in the Connecticut valley.] Proc. Boston soc. nat. hist., vol. 7, p. 49-53.

Brodie, P. B.

- '60. On the occurrence of footsteps of *Chirotherium* in the upper Keuper of Warwickshire. Ann. and mag. nat. hist., ser. 3, vol. 5, p. 4.

Buckland, W.

- '28. Note sur des traces de tortues observées dans le grès rouge. Ann. des sci. nat., vol. 13, p. 85-86.
'36. The Bridgewater treatises on the power, wisdom, and goodness of God as manifested in the creation. Treatise 6. Geology and mineralogy considered with reference to natural theology. London: 2 vols., 8vo.
(*"Fossil footsteps,"* vol. 1, p. 199-201.)
'39. An account of the footsteps of the *Cheirotherium* and five or six smaller animals in the stone quarries of Storeton hill, near Liverpool. Notices and abstracts of communications to British assoc. adv. sci., Newcastle meeting, 1838, vol. 7, p. 85.
'58. The Bridgewater treatises on the power, wisdom, and goodness of God, as manifested in the creation. Treatise 6. Geology and mineralogy considered with reference to natural theology. 3d ed., London: 2 vols., 8vo., illus.

Cook, G. H.

- '85. [List of species found at Whitehall, New Jersey.] Geol. surv. of New Jersey, ann. rept. state geologist for 1885, p. 96.

Cope, E. D.

- '67. [Account of extinct reptiles which approach birds.] Proc. acad. nat. sci. Philadelphia, 1867, p. 234-235.

Cotta, B.

- '39a. Notitz über thierfährten im bunten sandstein bei Pölzig zwischen Ronneburg und Weissenfels. Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1839, p. 10-15.
'39b. Ueber thierfährten im bunten sandsteine bei Pölzig im Altenburgischen. Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1839, p. 617.

Croiset, —.

- '35-'36. [On the footprints of Hessburg.] Bull. soc. géol. de France, vol. 7, p. 259-260.

Cunningham, J.

- '38a. [On the footprints of Liverpool.] London and Edinburgh philos. mag., vol. 14, p. 148.

¹ Including nearly all of the literature upon Triassic and Jurassic footprints.

- '38b. [An account of the footsteps of the *Chirotherium*.] Proc. geol. soc. London, vol. 3, p. 12-14.
- '46. On some footmarks [of birds] and other impressions observed in the new red sandstone quarries of Storton, near Liverpool. Quart. journ. geol. soc. London, vol. 2, p. 410.
- Cushman, J. A.
- :04. A new footprint from the Connecticut valley. Amer. geologist, vol. 33, p. 154-156, pl. 6.
(*Otouphepus magnificus*.)
- Dana, J. D.
- '95. Manual of geology. 4th ed., New York: 8vo; 1088 pp., illus.
(See p. 752-753.)
- Daubrée, A.
- '57. Découverte de traces de pattes de quadrupèdes dans le grès bigarré de Saint-Valbert, près Luxeuil (Haute-Saône). Comptes rendus hebdomadaires des séances de l'acad. des sci., Paris, vol. 45, p. 646-648.
- '58. Note sur la découverte de traces de pattes de quadrupèdes dans le grès bigarré de Saint-Valbert, près Luxeuil (Haute-Saône). Bull. soc. géol. de France, ser. 2, vol. 15, p. 218-221.
- Deane, James.
- '44a. On the fossil footmarks of Turner's Falls, Massachusetts. Amer. journ. sci. and arts, vol. 46, p. 73-77, pl. 1-2.
Abstract of, in Quart. journ. geol. soc. London, vol. 1, 1845, p. 141-142.
- '44b. On the discovery of fossil footmarks. Amer. journ. sci. and arts, vol. 47, p. 381-390.
- '44c. Answer to the "Rejoinder" of Prof. Hitchcock. Amer. journ. sci. and arts, vol. 47, p. 399-401.
- '45a. Description of fossil footprints in the new red sandstone of the Connecticut valley. Amer. journ. sci. and arts vol. 48, p. 158-167, pl. 3.
- '45b. Illustrations of fossil footmarks. Boston journ. nat. hist., vol. 5, p. 277-284, text fig. 1-3.
- '45c. Notice of a new species of batrachian footmarks. Amer. journ. sci. and arts, vol. 49, p. 79-81, text fig. A-B.
- '45d. Fossil footmarks and rain-drops. Amer. journ. sci. and arts, vol. 49, p. 213-215, one page of figs.
- '47a. Notice of new fossil footprints. Amer. journ. sci. and arts, ser. 2, vol. 3, p. 74-79, text fig. 1-4.
- '47b. Fossil footprints. Amer. journ. sci. and arts, ser. 2, vol. 4, p. 448-449.
- '48. Fossil footprints of a new species of quadruped. Amer. journ. sci. and arts, ser. 2, vol. 5, p. 40-41, 1 text fig.
- '47-'50. Fossil footprints of Connecticut river. Journ. acad. nat. sci. Philadelphia, ser. 2, vol. 2, p. 71-74, pl. 8-9.
- '56. On the sandstone fossils of Connecticut river. Journ. acad. nat. sci. Philadelphia, ser. 2, vol. 3, p. 173-178, pl. 18-20.
- '61. Ichnographs from the sandstone of Connecticut river. Boston: 4to, 61 pp., 46 pls.
- Degenhardt, —.
- '40. [Footprints of birds from Oiva, province of Socorro, Mexico.] Neues jahrb. f. mineral., geogn., geol., u. petrefak-tenkunde, 1840, p. 485.
- Dollo, L.
- '83. Troisième note sur les dinosauriens de Bernissart. Bull. mus. roy. d'hist. nat. de Belgique, vol. 2, p. 85-126, pl. 3-5.
- Duncan, H.
- '31. An account of the tracks and footmarks of animals found impressed on sandstone in the quarry of Corncockle Muir, in Dumfriesshire. Trans. roy. soc. Edinburgh, vol. 11, pt. 1, p. 194-209, pl. [8].
- Edwards, A. M.
- '95. Ornithichnites and jaw bone from the Newark sandstone of New Jersey. Amer. journ. sci., ser. 3, vol. 50, p. 346.
- Egerton, P. G.
- '38. [On the footprints of Liverpool.] London and Edinburgh philos. mag., vol. 14, p. 150.
- Emerson, B. K.
- '98. Geology of Old Hampshire county, Massachusetts, comprising Franklin, Hampshire, and Hampden counties. Monog. U. S. geol. surv., vol. 29, xxi + 790 pp., 35 pls.
(Ichnology, p. 400-404.)

Englehardt, —.

- '37. Ueber die formation, in welcher die tatzten-abdrücke vorweltlicher thiere in der nähe von Hildburghausen auftreten, und über das vorkommen dieser abdrücke. Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1837, p. 379-388.

Eyerman, J.

- '86. Footprints of the Triassic sandstone (Jura-Trias) of New Jersey. Amer. journ. sci., ser. 3, vol. 31, p. 72.
'89. Notes on geology and mineralogy. Proc. acad. nat. sci. Philadelphia, 1889, p. 32-35.

Field, R.

- '60a. Ornithichnites, or tracks resembling those of birds. Amer. journ. sci. and arts, ser. 2, vol. 29, p. 361-363.
'60b. Ornithichnites. Proc. Amer. assoc. adv. sci., 13th meeting, Springfield, p. 337-340.
'60c. [The footmarks of the Connecticut river sandstones.] Proc. Boston soc. nat. hist., vol. 7, p. 316-317.

Gaudry, A.

- '90. Les enchaînements du monde animal dans les temps géologiques. Fossiles secondaires. Paris: 8vo.; illus.
(On *Chirotherium*.)

Geinitz, H. B.

- '63. Ueber thierfährten und crustaceen-reste in der untern Dyas. Neues jahrb. f. mineral., geol., u. palaeontol., 1863, p. 118.
(See Oppel, 1862.)

Gervais, Paul.

- '57a. Sur des empreintes de pas laissées par plusieurs espèces d'animaux dans le terrain Triassique des environs de Lodève. Comptes rendus hebdomadaires des séances de l'acad. des sci., Paris, vol. 45, p. 763-765.
'57b. [On *Chirotherium barthi* and tridactyl tracks of Lodève.] L' Institute, vol. 25.

Giebel, C. G.

- '47-'56. Fauna der vorwelt mit steter berücksichtigung der lebenden thiere. Leipzig: 5 vols.
(See vol. 1, pt. 2, p. 34.)

Grabbe, H.

- '81. Neue funde von saurier-fährten im Wealdensandsteine des Bückebuges. Verhandl. d. naturhist. verein. d. preuss. Rheinlande und Westfalens, vol. 38, p. 161-164.

Haidinger, W.

- '41. Ueber eine neue art von vorweltlichen thierfährten. Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1841, p. 546-548, pl. 10.

Harkness, R.

- '50a. On the position of the impressions of footsteps in the Bunter sandstone of Dumfries-shire. Ann. and mag. nat. hist., ser. 2, vol. 6, p. 203-208.
'50b. Notice of a tridactylous footmark from the Bunter sandstone of Weston Point, Cheshire. Ann. and mag. nat. hist., ser. 2, vol. 6, p. 441-442.
'51. Notice of some new footsteps in the Bunter sandstone of Dumfries-shire. Ann. and mag. nat. hist., ser. 2, vol. 8, p. 90-95.

Hawkshaw, —.

- '43. New red sandstone of Lymm in Cheshire. L'Institute, vol. 11.

Hay, O. P.

- :02. Bibliography and catalogue of the fossil Vertebrata of North America. Bull. U. S. geol. surv., no. 179, p. 1-868.
(See p. 538-553.)

Hitchcock, C. H.

- '55. Impressions (chiefly tracks) on alluvial clay, in Hadley, Mass. Amer. journ. sci. and arts, ser. 2, vol. 19, p. 391-396.
'65. [Editorial notes and some new descriptions.] In Edward Hitchcock's Supplement to the ichnology of New England (see E. Hitchcock, '65).
'66. Description of a new reptilian bird from the Trias of Massachusetts. Ann. lyceum nat. hist. New York, vol. 8, p. 301-302.

- '71. [Account and complete list of the Ichnozoa of the Connecticut valley.] Walling and Gray's official topographical atlas of Massachusetts, p. xx-xxi.
- '73. Footprints in the rocks. Pop. sci. monthly, vol. 3, p. 428-441, text fig. 1-7.
- '89a. [Remarks on A. Wanner's paper on the discovery of fossil tracks in the Triassic of York county, Pa.] Proc. Amer. assoc. adv. sci., 37th meeting, Cleveland, 1888, p. 186.
- '89b. Recent progress in ichnology. Proc. Boston soc. nat. hist., vol. 24, p. 117-127.
- Hitchcock, Edward.
- '36. Ornithichnology.—Description of the footmarks of birds, (Ornithichnites) on new red sandstone in Massachusetts. Amer. journ. sci. and arts, vol. 29, p. 307-340, pl. [1] fig. 1-20, 23-24; pl. [2], fig. 21-22, pl. [3].
- '37a. Ornithichnites in Connecticut. Amer. journ. sci. and arts, vol. 31, p. 174-175.
- '37b. Fossil footsteps in sandstone and graywacke. Amer. journ. sci. and arts, vol. 32, p. 174-176.
- '41. Final report on the geology of Massachusetts. Northampton: 4to; 11 + 831 pp., illus. (See p. 458-525, pl. 29-51.)
- '43. Description of five new species of fossil footmarks, from the red sandstone of the valley of Connecticut river. Reports of the first, second and third meetings of assoc. of Amer. geologists and naturalists, p. 254-264, pl. 11.
- '44a. Report on ichnolithology, or fossil footmarks, with a description of several new species, and the coprolites of birds, from the valley of the Connecticut river, and a supposed footmark from the valley of Hudson river, Amer. journ. sci. and arts, vol. 47, p. 292-322, pl. 3-4. (Abstract in Neues jahrb. f. mineral., etc., 1845, p. 753-757.)
- '44b. Rejoinder to the preceding article of Dr. Deane. Amer. journ. sci. and arts, vol. 47, p. 390-399. (Reply to J. Deane, '44b.)
- '45a. Extract of a letter from Prof. E. Hitchcock, embracing miscellaneous remarks upon fossil footmarks, the lincolnite, &c. Amer. journ. sci. and arts, vol. 48, p. 61-65.
- '45b. An attempt to name, classify, and describe, the animals that made the fossil footmarks of New England. [Abstract.] Proc. 6th annual meeting assoc. Amer. geologists and naturalists, New Haven, Conn., April, 1845, p. 23-25.
- '47. Description of two new species of fossil footmarks found in Massachusetts and Connecticut, or, of the animals that made them. Amer. journ. sci. and arts, ser. 2, vol. 4, p. 46-57, text fig. 1-3.
- '48. An attempt to discriminate and describe the animals that made the fossil footmarks of the United States, and especially of New England. Mem. Amer. acad. arts and sci., new ser., vol. 3, p. 129-256, table, pl. 1-24.
- '55. Shark remains from the coal formation of Illinois, and bones and tracks from the Connecticut river sandstone. Amer. journ. sci. and arts, ser. 2, vol. 20, p. 416-417.
- '56. Description of a new and remarkable species of fossil footmark, from the sandstone of Turner's Falls, in the Connecticut valley. Amer. journ. sci. and arts, ser. 2, vol. 21, p. 97-100, 1 text fig.
- '58. Ichnology of New England. A report on the sandstone of the Connecticut valley, especially its fossil footmarks, made to the government of the Commonwealth of Massachusetts. Boston: 4to; xii + 220 pp., 60 pls.
- '61. Remarks upon certain points in ichnology. Proc. Amer. assoc. adv. sci., 14th meeting, Newport, 1860, p. 144-156, text fig. 1-4.
- '63. New facts and conclusions respecting the fossil footmarks of the Connecticut valley. Amer. journ. sci. and arts, ser. 2, vol. 36, p. 46-57, text fig. 1-2.
- '65. Supplement to the Ichnology of New England. Boston: 4to; x + 96 pp., 20 pls.
- '66. Supplement to the Ichnology of New England. Proc. Amer. acad. arts and sci., vol. 6, p. 85-92.
- Hornstein, F.
- '76. [On *Chirotherium geinitzi* of Karlshafen.] Neues jahrb. f. mineral., geol., u. palaeontol., 1876, p. 923-924.
- von Humboldt, A.
- '35. Note sur des empreintes de pieds d'un quadrupède dans la formation de grès bigarré de Hildburghausen en Allemagne. Ann. des sci. nat., zool., ser. 2, vol. 4, p. 135-138, pl. 5.
- Huxley, T. H.
- '59. On the *Stagonolepis robertsoni* (Agassiz) of the Elgin sandstones; and on the recently discovered footmarks in the sandstones of Cummingstone. Quart. journ. geol. soc. London, vol. 15, p. 440-460, pl. 14.

Jardine, W.

'50. Note to Mr. Harkness's paper on "The position of the impressions of footsteps in the Bunter sandstone of Dumfries-shire." Ann. and mag. nat. hist., ser. 2, vol. 6, p. 208-209. (See R. Harkness, '50a.)

'53. The ichnology of Annandale or illustrations of footmarks impressed on the new red sandstone of Corncockle Muir. Edinburgh.

Jeffs, O. W.

'94. On a series of saurian footprints from the Cheshire Trias (with a note on Cheirotherium). Geol. mag., London ser. 4, vol. 1, p. 451-454.

Kaup, J. J.

'35. [On the footprints of Hessburg.] Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1835, p. 327-328.

'35-'37. Das thierreich in seinem hauptformen systematisch beschrieben. 3 vols. Darmstadt.
(See vol. 1, p. 246.)

Kent, W. Saville.

'97. The naturalist in Australia. London: xvi + 302 pp., 50 pls.

Kölonische zeitung.

'35. [On the footprints of Hessburg.] Verhandl. der mineralogische geognostischen section während der versammlung deutscher naturforscher und ärzte in Bonn. Kölonische zeitung, 1835, no. 276.

Laspe, —.

'39. Ueber eine neue thierfährte im bunten sandsteine bei Gera. Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1839, p. 416-417, pl. 8A.

von Leonard, K. C.

'28. Schildkröten-spuren in rothen Flöz-sandstein. Zeitschr. f. mineral., vol. 1.

Lesley, J. P.

'89-'90. A dictionary of the fossils of Pennsylvania and neighboring states named in the reports and catalogues of the survey. Geol. surv. Pennsylvania, rept. P 4, 1889. 3 vols., illus.

Link, —.

'35. Note sur des traces de pattes d'animaux inconnus contre-épreuvees dans le grès, près de Hildburghausen. Ann. des sci. nat., zool., ser. 2, vol. 4, p. 139-141.

Lortet, L.

'92. Les reptiles fossiles du bassin du Rhone. Archiv. mus. de l'hist. nat. Lyons, vol. 5, p. 1-139, pl. 1-12.
(On Chirotherium, p. 125, pl. 12.)

Lucas, F. A.

:01. Animals of the past. New York: illus.
(See p. 33-47, with 1 plate.)

Lyell, C.

'66. Elements of geology. 6th ed. New York: xvi + 803 pp.; illus.
(See p. 398.)

Mantell, G. A.

'46. Description of footmarks and other imprints on a slab of new red sandstone, from Turner's Falls, Massachusetts, U. S., collected by Dr. James Deane of Greenfield, U. S. Quart. journ. geol. soc. London, vol. 2, p. 38.

Marsh, Dexter.

'48. Fossil footprints. Amer. journ. sci. and arts, ser. 2, vol. 6, p. 272-274, 1 text fig.

Marsh, O. C.

'89. Notice of some new American Dinosauria. Amer. journ. sci., ser. 3, vol. 37, p. 331-336, text fig. 1-5.
(*Ammosaurus* (*Anchisaurus*) *major*.)

'91. Notice of new vertebrate fossils. Amer. journ. sci., ser. 3, vol. 42, p. 265-269.
(*Ammosaurus* and *Anchisaurus*, p. 267.)

'92. Notes on Triassic Dinosauria. Amer. journ. sci., ser. 3, vol. 43, p. 543-546, pl. 15-17.

'93. Restoration of *Anchisaurus*. Amer. journ. sci., ser. 3, vol. 45, p. 169-170, pl. 6.

- '95. On the affinities and classification of the dinosaurian reptiles. Amer. journ. sci., ser. 3, vol. 50, p. 483-498, text fig. 1-11, pl. 10.
- '96. The dinosaurs of North America. 16th ann. rept. U. S. geol. surv., 1894-'95, pt. 1, p. 133-414, text fig. 1-66, pl. 2-85.
(On the footprints: p. 146-147, fig. 2, and p. 151, pl. 5. On the Anchisauridae: p. 147-151, pl. 2-4.)
- '99. Footprints of Jurassic dinosaurs. Amer. journ. sci., ser. 4, vol. 7, p. 227-232, text fig. 1-3, pl. 5.
- Milne-Edwards, A.
- '63. Mémoire sur la distribution géologique des oiseaux fossiles et description de quelques espèces nouvelles. Ann. des sci. nat., zool., ser. 4, vol. 20, p. 133-176, pl. 4.
- Mitchell, J. A.
- '95. The discovery of fossil tracks in the Newark system (Jura-Trias) of Frederick county, Maryland. Johns Hopkins univ. circulars, vol. 15, no. 121, p. 15-16.
- Mudge, B. F.
- '66. Discovery of fossil footmarks in the Liassic (?) formation in Kansas. Amer. journ. sci. and arts, ser. 2, vol. 41.
(No names are given. C. H. Hitchcock regards them as artifacts).
- '74. Recent discoveries of fossil footprints in Kansas. Reprint of above, Trans. Kansas acad. sci., 1873, p. 7-9.
- Murchison, R. L., & Strickland, H. E.
- '40. On the upper formations of the new red sandstone system in Gloucestershire, Worcestershire, and Warwickshire; showing that the red or saliferous marls, including a peculiar zone of sandstone, represent the "Keuper" or "marnes irisées"; with some account of the underlying sandstone of Ombersley, Bromsgrove, and Warwick, providing that it is the "bunter sandstein" or "grès bigarré" of foreign geologists. Trans. geol. soc. London, ser. 2, vol. 5, p. 331-348, 1 text fig., pl. 28.
- Nicholson, H. A., & Lydekker, R.
- '89. A manual of palaeontology. 3d ed., Edinburgh and London: 2 vols.; illus.
(Vol. 2, p. 1038-1039, fig. 970 *bis*, *Chirotherium*.)
- Oppel, A.
- '62. Ueber fährten im lithographischen schiefer. Palaeontologische mittheilungen aus dem museum des königlichen bayerischen staates, pt. 2, 1862, p. 121-125, pl. 39. Stuttgart.
(*Ichnites lithographicus* possible track of *Archaeopteryx*.)
- Osborn, H. F.
- :00. Reconsideration of the evidence for a common dinosaur-avian stem in the Permian. Amer. nat., vol. 34, p. 777-799, text fig. 1-12.
- :03a. The reptilian subclasses Diapsida and Synapsida and the early history of the Diaptosauria. Mem. Amer. mus. nat. hist., vol. 1, pt. 8, p. 451-507, text fig. 1-23.
- :03b. *Ornitholestes hermanni*, a new Compsognathoid dinosaur from the upper Jurassic. Bull. Amer. mus. nat. hist., vol. 19, p. 459-464, text fig. 1-3.
- Owen, Richard.
- '42. [On footprints of upper new red sandstone of Greensell.] Trans. Cambridge philos. soc., vol. 7, p. 355.
- Pabst, W.
- '96. Die thierfährten in dem oberrothliegenden von Tambach in Thüringen. Zeitschr. d. deutsch. geol. gesellsch. Berlin, vol. 48, p. 808-829, text fig. 1-10, pl. 17-20.
- Pictet, F. J.
- '53-'57. Traité de paléontologie. 2d ed., Paris: 4 vols., atlas.
(See vol. 1, 1853, p. 406, pl. 20.)
- Plieninger, —.
- '38. [On footprints of Stuttgart.] Bericht über der versammlung deutscher naturforscher u. ärzte in Prague, 1837. p. 132-133.
- Quenstedt, F. A.
- '52. Handbuch der petrefaktenkunde. Tübingen; illus.
(See p. 81.)

- '85. Handbuch der petrefaktenkunde. 3d ed, Tübingen: illus.
(See p. 128-133, with figures. A summary.)
- Rogers, H. D., *et al.*
- '42. Report on the ornithichnites or footmarks of extinct birds in the new red sandstone of Massachusetts and Connecticut, observed and described by Prof. Hitchcock, of Amherst. Ann. and mag. nat. hist., vol. 8, p. 235-238
- Rumpf, —.
- '42. [On footprints of *Aura* on the Saal.] Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1842, p. 450-451.
- '43. [On footprints of *Aura* on the Saal.] Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1843, p. 705-707.
- Schwabe, S. H.
- '54. [On the footprints of *Chirotherium* of Altenburg.] Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1854, p. 569-570.
- Sickler, F. K. L.
- '34. Sendschreiben an J. F. Blumenbach, über die höchst merkwürdigen, vor einigen monaten erst entdeckten reliefs der fährten urweltlicher grosser unbekannter thierte in den Hessberger sandsteinbrüchen, bei der stadt Hildburghausen. Hildburghausen: 4to.; 16 pp., illus.
- '35. [On the footprints of Hessburg.] Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde. 1835, p. 230-232.
- '36. Die vorzüglichsten fährten-abdrücke urweltlicher thierte, im buntem sandsteine aus den sandsteinbrüchen der umgegend von Hildburghausen. Hildburghausen.
- Smith, G. V.
- '84. On further discoveries of the footprints of vertebrate animals in the lower new red sandstone of Penrith. Quart. journ. geol. soc. London, vol. 40, p. 479-481, 1 text fig.
- Sollas, W. J.
- '79. On some three toed footprints from the Triassic conglomerate of South Wales. Quart. journ. geol. soc. London, vol. 35, p. 511-516, 1 text fig.
(*Brontozoum thomasi*.)
- Struckmann, C.
- '80. Vorläufige nachricht über das vorkommen grosser vogelähnlicher thierfährten (Ornithoidichnites) im Hastings sandsteine von Bad Rehburg bei Hannover. Neues jahrb. f. mineral., geol., u. palaeontol., 1880, vol. 1, p. 124-128, pl. 4.
- Tylor, Alfred.
- '62. On the footprint of an *Iguanodon*, lately found at Hastings. Quart. journ. geol. soc. London, vol. 18, p. 247-253, 2 text figs., and diagrams.
- Virlet, Th.
- '35-'36. Note sur les empreintes de pieds d'animaux dans le grès bigarré des environs de Hildburghausen, en Saxe. Bull. soc. géol. de France, vol. 7, p. 220-224, also note on this paper, p. 260.
(On the *Chirotherium* tracks of Hessburg.)
- Voight, F. S.
- '32. [On the footprints of Hessburg.] Almanach der natur, 1832, p. 137.
- '35. [On the footprints of Hessburg.] Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1835, p. 322-326.
- '36. Weitere nachrichten über die Hessberger thierfährten. Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1836, p. 166-174, pl. 3.
- Wagner, —.
- '60. [Footprints of *Chirotherium barthi* of Harmerz.] Neues jahrb. f. mineral., geogn., geol., u. petrefaktenkunde, 1860, p. 693.
- Wanner, Atreus.
- '89. The discovery of fossil tracks, algae, etc., in the Triassic of York county, Pennsylvania. Ann. rept. geol. surv. Pennsylvania, 1887, p. 21-35, pl. 3-13. Abstract in Proc. Amer. assoc. adv. sci., 1888, p. 186.
- '92. Fossil tracks in the Trias of York co., Pa. Proc. Amer. assoc. adv. sci., Washington meeting, 1891, p. 286.
(Abstract.)

Ward, Ogier.

'40. [On the footprints of Greensell]. L'Institut, 1840, p. 219.

Warren, J. C.

'54. Remarks on some fossil impressions in the sandstone rocks of Connecticut river. Boston: 54 pp., illus.

'56. [On new remarkable gigantic fossils and footmarks.] Proc. Boston soc. nat. hist., vol. 5, p. 298-306.

Wiegmann, A. F. A.

'35. Thierfährten im bunten sandsteine. Archiv f. naturgesch., 1835, vol. 1, p. 127-131, 395-397.

Williamson, W. C.

'67. On a Cheirotherian footprint from the base of the Keuper sandstone of Daresbury, Cheshire. Quart. journ. geol. soc. London, vol. 23, p. 56-57, pl. 3.

Winkler, C.

'86. L'histoire d'ichnologie. Haarlem.

(Historical résumé of the ichnological science, p. 1-187; footprints of Hessburg in the Musée Teyler, p. 188-192, pl. 1-9; impressions in the lithographic limestone of the Musée Teyler, p. 193-200, pl. 11.)

Woodworth, J. B.

'95. Three toed dinosaur tracks in the Newark group at Avondale, N. J. Amer. journ. sci., ser. 3, vol. 50, p. 481-482.

Yates, —.

'38. On the footprints at Liverpool. London and Edinburgh philos. mag., vol. 14, p. 150.

von Zittel, K. A.

'80-'93. Handbuch der palaeontologie. 4 vols. München und Leipzig.

(See vol. 3, 1890, p. 409-411.)

EXPLANATION OF THE PLATE.

PLATE 72.

Figs A and B. *Chirotherium barthi* Kaup. Impressions of the right manus and pes, $\times \frac{1}{4}$, with a provisional restoration of the skeleton. Drawn from a photograph of a specimen in the British museum (R. 728).

Figs. C and D. *Chirotherium storetonensis*. Impression of the right manus and pes. $\times \frac{1}{4}$. From specimen no. $\frac{3}{2}$, in the Hitchcock cabinet.

Fig. E. *Otozoum moodii* E. Hitchcock. Imprint of the right manus. $\times \frac{1}{4}$. From the type specimen, no. $\frac{5}{14}$, in the Hitchcock cabinet. The bone restoration is highly conjectural.

Fig. F. *Otozoum moodii* E. Hitchcock. Impression of the right pes. $\times \frac{1}{4}$. Drawn from a specimen preserved in the Geological museum of Amherst college. The specimen has been so trimmed as to destroy most of the web.

Fig. G. *Otozoum moodii* E. Hitchcock. Imprint of the right pes. $\times \frac{1}{4}$. From the specimen no. $\frac{4}{1}$, of the Hitchcock cabinet, showing the full development of the web. The broken line (---) indicates the variation between successive tracks of the same foot. The skeleton restoration is somewhat conjectural.

Signs referring to all the figures: ——— pad and web outline; ----- outline of claws; ----- outline of variation; ----- restored outline; ----- broken edge of slab.

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Generic and specific names regarded as synonyms are printed in italics. The asterisk (*) indicates the page upon which the species is figured, while that bearing the description of the form is designated by bold faced numerals.

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